SITE-SPECIFIC RISK ASSESSMENT

Former Kop-Flex Facility
Hanover, Maryland
July 7, 2015

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Client

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1 Introduction

WSP USA Corp. (WSP), on behalf of Emerson, prepared this site-specific risk assessment (SSRA) for the former Kop-Flex facility located at 7565 Harmans Road in Hanover, Maryland. The SSRA evaluates potential human health and ecological risks from chemicals of potential concern (COPCs) identified in media at the site. The SSRA was prepared in accordance with the Maryland Department of the Environment (MDE) Voluntary Cleanup Program (VCP) Guidance Document (MDE 2006) and the U.S. Environmental Protection Agency (EPA) Risk Assessment Guidance for Superfund (RAGS), pursuant to the MDE VCP Guidance.

Two previous risk assessments were prepared for this property by Environmental Strategies Corporation (ESC 1999b) and WSP (2009). The current SSRA was undertaken to incorporate additional investigation results since 2009, changes in planned property use from industrial to commercial, and the most current toxicity information and risk characterization methods.

The following activities were completed as part of the SSRA:

- Data from previous investigation and remedial activities were evaluated to identify relevant information on COPCs in environmental media.
- The results of the previous site investigation were used to develop a conceptual site model (CSM). Risks to human health from exposure to COPCs were evaluated based on an identification of hazards, evaluation of exposures, evaluation of the toxicity of COPCs, and calculations of risks.
- Ecological risks were evaluated by an assessment of exposure pathways and comparison between concentrations in environmental media and relevant screening levels.

2 Site Background

This section provides a description of the general site characteristics, history, geology and hydrogeology.

2.1 General Description

The former Kop-Flex facility is located at 7565 Harmans Road in Hanover, Maryland (Figure 1). The facility occupies an approximately 25-acre parcel with two buildings (Figure 2). The parcel is currently owned by EMERSUB 16, LLC, a subsidiary of Emerson Electric Co. (Emerson). This report will refer to the parcel as the "Kop-Flex property."

The main building on the property consists of an approximately 220,000-square-foot former manufacturing and office building. A second building is an approximately 20,000-square-foot former forge near the eastern property boundary. The property is zoned W-3, or industrial, heavy, and will be re-zoned for commercial use during the anticipated re-development of the property. The adjacent properties to the north, east and south are zoned industrial (W-1, W-2, and W-3), and the surrounding properties are zoned residential (R-1, R-2, and R-5) (Anne Arundel County Planning and Zoning 2008).

The property is bordered to the north by a Verizon Communications maintenance facility; to the east by the a mobile office rental and repair facility operated by Williams-Scotsman followed by Penn Central railroad tracks; to the south by the Williams Scotsman facility followed by Maryland State Route 100; and to the west by undeveloped land along Stony Run, a tributary of the Patapsco River, followed by Harmans Road and then a residential area. A sand and gravel mining pit is located approximately 1,000 feet south and southeast of the site. The closest residence to the subject property is located approximately 1,800 feet to the southwest.

Kop-Flex formerly manufactured flexible couplings, including precision forging, for the power transmission industry. Construction of the main facility was completed in 1969 by the Koppers Company, Inc., which operated the site until 1986, and the forge building was added in 1979. In 1986, a group of employee managers and an investment company acquired the facility, along with the business it supported, from Koppers. The newly acquired business eventually changed its name ti Kop-Flex, Inc. In 1996, Emerson acquired Kop-Flex and continued operations until early 2012, when manufacturing activities ceased at the plant. The facility has been fully decommissioned and is currently unused, except for the office building which is occupied by a small number of former Kop-Flex staff. The office operations will be moved to another location in the Baltimore area in the next few months. The property is currently under contract to be purchased by Trammell Crow.

2.2 Environmental Setting

2.2.1 Topography and Surface Water Drainage

The elevation of the site is approximately 125 feet above mean sea level (ft AMSL). Although the general topography of the site is flat, the main building sits on a topographical high that was reportedly created during construction. The closest body of surface water is Stony Run, which crosses the western portion of the site (Figure 2). The 100-year flood plain of Stony Run includes a portion of the parking lot northwest of the main building. Stony Run flows north across Dorsey Road, located approximately 2,000 feet north of the property, through the Baltimore Commons Business Park (part of Baltimore-Washington International Airport property), and Patapsco State Park before discharging into the Patapsco River, 7 miles to the north (Figure 1). Wetlands are not present on the Kop-Flex property.

2.2.2 Regional Geologic and Hydrogeologic Framework

The site is located within the Atlantic Coastal Plain physiographic province. In Anne Arundel County, Maryland, this province is characterized by alternating layers of Cretaceous age sand and clay sediments that dip gently to the southeast (Mack and Achmad, 1986). Aquifer formations in this province range from several tens to hundreds of feet thick. The sandy Cretaceous aquifers within the Maryland Coastal Plain are heavily used as both public and private water sources.

2.2.3 Site Geology

Geologic cross-section locations and the actual cross-sections are shown in Figures 3 and 4. Lithologically, the siliciclastic deposits present to a depth of 150 feet below ground surface (bgs) at the site consist of a complexly interbedded and inter-fingering sequence of predominantly coarse-grained (sand with gravel and fines) and fine-grained (silt and clay) units. On a general, site-wide scale, the identified lithologies can be grouped into three gross stratigraphic units, which for the purposes of this discussion are generically termed upper, middle, and lower. The upper-most unit is comprised primarily of sand, with variable fines content, to gravelly sand along with occasional localized lens of silt and clay sediments. This shallow sandy unit appears to be thickest in the southeastern portion of property and thins to the north and west. Given the stratigraphic relationships with the clayey deposits in the shallow subsurface, it is believed the sandy sediments present to a depth of approximately 10 feet over most of the site represent fill material emplaced prior to development. The upper sand unit is underlain by a stratigraphic interval characterized by variable thickness and significant lateral and vertical heterogeneity. Overall, this middle unit consists of predominantly fine-grained sediments, with lithologies ranging from silty to sandy clay to clayey to sandy silt to finely inter-laminated sand and clay. Occasional sand zones may exist as isolated bodies within the fine-grained sediments, or inter-fingered to interbedded layers that reflect the gradational transition between the overlying and underlying stratigraphic units. Based on the boring logs, the maximum thickness of the fine-grained middle unit occurs along the southern property boundary (see Section B-B’ in Figure 4). The middle stratigraphic unit grades downward to another unit consisting primarily of sand and gravelly sand deposits with rare, discontinuous layers of sandy to clayey silt sediments of variable thickness. Correlation of the borehole lithologic data indicates the gravelly sand deposits are more aerially extensive than similar lithofacies in the upper sand unit. Consistent with the regional geologic framework, the differentiated stratigraphic units appear to dip (i.e., increase in depth) from the northern to the southern portion of the site.

2.2.4 Site Hydrogeology

Water level measurements from shallow monitoring wells indicate that groundwater is encountered at a depth of 10-15 feet bgs at the site, although depths may be slightly greater in the eastern portion of the property and slightly lower northwest of the main building near Stony Run (Figure 4). Portions of the stratigraphic sequence consisting of predominantly coarse-grained (sand) lithologies characterized by high porosity and permeability form the primary zones for the movement of groundwater. The inter-layered fine-grained silt and clay deposits represent zones of more limited flow within the unconsolidated sequence. Evaluation of head data for the shallow and intermediate depth monitoring wells indicates relatively good hydraulic communication between the upper sand unit and the inter-bedded coarse and fine grained deposits of the middle unit to depth of approximately 60 feet bgs. Given the significant head difference between the intermediate and deep (‘D’ series) wells, the hard, dense clayey deposits encountered below 60 feet bgs within the middle unit appear to serve as a semi-confining unit, or aquitard, separating the overlying deposits and underlying lower sand unit. Based on the thickness and orientation of the stratigraphic units underlying the site, the lower sand zone is inferred to be the upper-most portion of the Lower Patapsco Aquifer and the hard, dense clayey deposits of the middle fine-grained unit are believed to be the Patapsco Confining Unit which separates the Lower and Upper Patapsco aquifers. The unconsolidated sediments present at depths above 60 feet probably represent a combination of more recent (Quarternary) deposits along with the older Cretaceous lithofacies.

Groundwater in the upper sand unit and inter-fingered sand-silt-clay deposits in the western portion of the site is unconfined. Contouring of the groundwater surface indicates flow in a generally westward direction toward Stony

Run, which is believed to be the discharge point for shallow groundwater Groundwater in the lower sand unit occurs under semi-confined conditions, with the depth to water in wells ranging from approximately 35 to 40 feet bgs. Based on contouring of water level data for the ‘D’ wells, the direction of groundwater flow within this portion of the Lower Patapsco Aquifer is to the south southeast.

Based on the consistent head differences observed in wells screened within the different portions of the hydrostratigraphic sequence, the confining unit separating the unconfined and semi-confined zones appears to be a good aquitard. However, the apparent downward migration of VOC-affected groundwater indicates the presence of vertical flow pathways. Laterally discontinuous clay lenses and silty/sandy clay zones within the confining unit have been identified in borehole logs and geologic cross sections. The downward hydraulic gradient and vertical flow pathways between the water-bearing zones are consistent with downward migration of COPCs.

3 Previous Investigations, Remedial Measures, and Risk Assessments

Environmental conditions on the property have been investigated from 1996 to the present. Data generated by these investigations and used in the SSRA are summarized in Appendix A (soil), Appendix B (soil vapor and indoor air), and Appendix C (surface water and sediment).

3.1 Phase I Assessment (1996)

ESC prepared a Phase I environmental assessment of the property (ESC 1996) which identified the following eight potential areas of concern (AOCs) where releases of oil or hazardous materials may have occurred:

- AOC 1 – chemical product and metal chip storage area
- AOC 2 – caustic wastewater treatment area
- AOC 3 - forge building transformers and metal scale locations
- AOC 4 – forge washwater collection tank
- AOC 5 – aboveground diesel fuel storage tank
- AOC 6 – former sanitary wastewater treatment plant
- AOC 7 – oil cooling unit spill remediation plant
- AOC 8 – floor of the Kop-Flex facility

3.2 Initial Phase II Investigation (1996 to 1998)

ESC conducted an initial Phase II investigation at the facility between 1996 and 1998 (ESC 1999a). The investigation consisted of soil and groundwater sampling, geologic characterization, the installation and sampling of 13 monitoring wells, and collection of surface water and sediment samples from Stony Run. The soil sampling results were compared to EPA Region 3 risk-based concentrations for commercial/industrial soil (EPA 1998) and to soil screening levels for migration to groundwater (EPA 1996). The investigations identified site-related chemicals of concern consisting primarily of chlorinated volatile organic compounds (VOCs) and petroleum hydrocarbons in soil and groundwater. Concentrations above screening levels were identified in AOC-2, AOC-4 and AOC-7 (Figure 2). In addition, VOC concentrations above the comparative criteria were detected in subsurface soil below a machining area in the southwest portion of the manufacturing building in the immediate vicinity of AOC 1.

3.3 Risk Assessment (1999)

ESC prepared an assessment of human health and ecological risks (ESC 1999b), based on the results of the Phase II investigation. Concentrations of VOCs and other chemicals of concern in soil, groundwater, surface water, and sediment were compared to relevant screening levels. The screening identified COPCs consisting mainly of chlorinated VOCs in soil and groundwater.

Future use of the property was assumed to remain industrial. The assessment identified the following potential complete exposure pathways:

- direct contact with surface soil (depth up to 3 feet) by a facility worker or visitor
- direct contact with surface and subsurface soil by a construction worker

- vapor intrusion due to VOC-containing soil and groundwater

Surface soil samples did not exceed screening levels for chemicals other than arsenic, concentrations of which were found to be consistent with site-specific background. Subsurface soil in a small “hot spot” area within AOC 1 contained VOC concentrations above screening levels for industrial properties, suggesting potential risk to construction workers, but this risk was judged to be minimal due to the small area and the location beneath the building. This soil was subsequently removed during a remedial action.

Groundwater was not anticipated to be used as a source of water on the property and is more than 10 feet below the surface, so there were no complete exposure pathways involving groundwater consumption or direct contact. Vapor intrusion was evaluated using the Johnson and Ettinger (1991) model and the associated EPA spreadsheets (EPA 2004a). Potential risks due to vapor intrusion from chlorinated VOCs in soil and groundwater were identified.

In the ecological risk assessment (ERA), no complete exposure pathways involving terrestrial receptors were identified. Potential aquatic receptors in nearby Stony Run were evaluated based on a comparison of chemical concentrations in surface water and sediment samples downstream of the facility to screening levels and to concentrations in upstream samples. No significant adverse effects on Stony Run were identified.

3.4 Dual Phase Extraction System (1999 to 2013)

In 1999, a dual phase extraction (DPE) and soil vapor extraction (SVE) pilot test was conducted in the southwest portion of the manufacturing building (AOC 1) to determine the design parameters for a full-scale system to address chlorinated VOC-containing soil and shallow groundwater (ESC 2001a). The DPE-SVE system was installed in 2001 and started up in 2002 after acquisition of the required National Pollution Discharge Elimination System (NPDES) permit. The DPE/SVE system removed chlorinated solvents from the vadose zone and shallow groundwater in AOC 1 and operated until November 2013. In conjunction with this remedial measure, a well ring, located beneath the floor in AOC 1, which was believed to be a source of the identified VOCs, was investigated and subsequently removed in February and March of 2001.

3.5 Unterdruck-Verdampfer-Brunnen System (1999-2004)

An Unterdruck-Verdampfer-Brunnen (UVB) pilot test was conducted in August and September 1999 to determine the full-scale design parameters for a system to remediate the area of VOC-containing groundwater east of the manufacturing building (AOC 2; Figure 2). The full-scale UVB system, consisting of four UVB wells, was installed in March of 2001 and operated until approximately July 2004 (ESC 2001b).

3.6 Additional Surface Water Sampling (2001)

ESC collected surface water samples from two locations in Stony Run in 2001, to supplement the 1998 Phase II surface water sampling. The samples were analyzed for VOCs, and none were detected.

3.7 Additional Soil and Groundwater Investigations (2004-present)

Beginning in July 2004, a series of investigations were conducted to evaluate potential additional sources and extent of VOCs, mostly in AOC 2. These investigation activities included the following:

- further characterization of geologic conditions and evaluation of potential unidentified sources of 1,1,1-tricholoroethane (TCA; July 2004)
- investigation of the former keyseater machine area (September 2005)

- groundwater profiling and investigation of the bedding materials and surrounding unconsolidated deposits associated with underground utilities (2006)
- investigation of the bedding materials and surrounding unconsolidated deposits associated with the storm water sewer line (March 2007)
- potential source area investigations inside and outside the manufacturing building (August 2007)
- further source area assessment along the eastern limit of the building (May 2008)

The additional investigations identified a VOC-impacted soil area immediately to the east of the building at approximately 7 feet bgs. This source was determined to be associated with the groundwater impacts to the east of the manufacturing building which previously were thought to have been associated with discharges of wastewater in the area between the main building and former forge shop.

Subsequent to 2009, investigations were conducted to gather hydrogeologic and groundwater quality data, particularly for the deeper water-bearing zone at the site. These investigations included the installation and semi-annual sampling of six intermediate-depth (approximately 40 to 60 feet bgs) monitoring wells and seven deep (approximately 95 feet bgs and deeper) wells. In addition, one deep monitoring well was installed on the adjacent Williams-Scotsman property immediately south of the Kop-Flex facility.

3.8 Soil Vapor and Indoor Air Sampling (2009)

In May 2009, sub-slab soil vapor and indoor air samples were collected to evaluate the vapor intrusion pathway in the main manufacturing building. At the time the sub-slab soil vapor and indoor air samples were collected, the SVE system was not operational; therefore, these air samples are representative of conditions beneath and in the building without the influence of the SVE system.

3.9 Risk Assessment (2009)

A revised risk assessment (WSP 2009) was prepared to update the 1999 risk assessment and include all available investigation results, as well as updated screening levels and toxicity values. This assessment also assumed future use of the property would remain industrial. Contaminants in surface soil were found to pose no significant risks to facility workers or visitors. Complete exposure pathways involving groundwater use were not identified.

The soil vapor and indoor air samples collected in June 2009 and were used to assess potential vapor intrusion risks. Although several compounds were detected in soil vapor samples above the screening levels for industrial air, only one compound (1,2,4-trimethylbenzene) was detected above a screening level in an indoor air sample. A quantitative evaluation was conducted of the risks due to indoor air inhalation. Risks to a utility worker from inhalation of vapors from groundwater in a trench were also evaluated. The risks to a facility worker or utility worker were found to be within or below target ranges.

Ecological risk associated with contaminants in surface water and sediment was also evaluated. As in the previous assessment, concentrations were found to be similar in upstream and downstream samples or below applicable screening levels.

3.10 Supplemental Investigations (2012-2013)

Additional soil and groundwater samples were collected from December 2012 through March 2013, to further characterize the extent of VOCs in soil and groundwater in AOC 1 and AOC 2 (WSP 2013). Fifteen soil borings were installed in these areas. Soil samples were collected at and below the depths where maximum organic vapor concentrations were detected. Grab groundwater samples were collected from the borings using depth-discrete samplers. A deep monitoring well was also installed and sampled in the AOC 1 area. Soil and groundwater samples were found to contain elevated concentrations of TCA, the degradation products 1,1-dichloroethane (1,1-DCA) and 1,1-dichloroethene (1,1-DCE), and 1,4-dioxane.

3.11 Additional Remedial Actions (2013-2014)

In 2013 and 2014, additional remedial activities were conducted to reduce potential VOC mass remaining in soils that could migrate to groundwater and to reduce the highest VOC concentrations in shallow groundwater (WSP 2014a). In AOC 2, emulsified zero valent iron (EZVI) was injected into the saturated zone to promote abiotic and microbial reductive dechlorination of chlorinated VOCs in the shallow groundwater. In AOC 1 and AOC 2, soil was excavated to depths of ranging from 15 to 23 feet bgs to remove the known source areas. Appendix A includes drawings showing the areas from which soil was excavated. The excavated soil was stockpiled, characterized, and transported offsite for disposal. Soil containing less than 1 milligram per kilogram (mg/kg) of total VOCs (approximately 89 cubic yards from AOC 1 and 247 cubic yards from AOC 2) was returned to the excavations, along with imported fill (2,009 cubic yards). The remaining soil with total VOC concentrations exceeding 1 mg/kg (3,116 tons from AOC 1 and 766 tons from AOC 2) was disposed of in offsite landfills.

3.12 Pre-Development Investigation (2014)

ECS Mid-Atlantic, LLC installed 13 soil borings to a depth of 6 feet bgs in September 2014, in conjunction with planned site development. The samples were collected in a future loading dock area between two planned warehouse buildings, where excavation is anticipated to a maximum depth of 4 feet bgs. Samples were collected from 10 of the borings and analyzed for VOCs, polycyclic aromatic hydrocarbons, gasoline-range and diesel-range petroleum hydrocarbons, polychlorinated biphenyls (PCBs), and metals. The samples contained non-detectable or trace concentrations of the organic parameters and metal concentrations below Maryland residential soil cleanup standards (MDE 2008; except slightly elevated arsenic in two samples).

3.13 Offsite Groundwater Investigation (2013 - 2015)

Based on the sampling results for the deep monitoring well on the Williams-Scotsman property, MDE requested the sampling of potable water supply wells in the area south of Kop-Flex property and Maryland Route 100. A total of 175 potable water supply wells were sampled during three phases from late 2012 through early 2015. Water samples from eight wells had site-related VOC concentrations above either the federal/state groundwater quality standards, or MDE risk-based criteria. These impacted potable wells were decommissioned, and the homes connected to the municipal water system by Emerson.

Additional groundwater investigation activities were conducted in the summer of 2014 and involved the installation of a total of nine monitoring wells in five different areas south of Route 100. Shallow unconfined wells were installed at two of the five locations, with the remaining wells completed to depths of greater than 100 feet bgs. During installation of the deep well borehole at each location, groundwater profiling was conducted to provide depth-discrete sample data to evaluate the vertical distribution of site-related VOCs and guide construction of the monitoring well(s) at each location. These groundwater samples were field screened for 1,1-dichloroethene using compound-specific colorimetric tubes and submitted to an offsite laboratory for VOC analysis on an expedited (less than 24-hour) turn-around time. Overall, the highest VOC concentrations were detected in samples from depths of greater than 100 feet bgs at the northern-most well location. Traces to very low concentrations of site-related VOCs were detected in a limited number of deep samples from hydraulically downgradient locations.

After completing the well installation activities, quarterly groundwater sampling events have been conducted to gather initial data on VOC concentrations in the deep aquifer. The offsite monitoring wells have been sampled in September 2014, December 2014, and March 2015. In conjunction with each sampling event, depth to water measurements were obtained from the offsite wells and selected onsite wells to determine hydraulic heads within the aquifer system.

4 Conceptual Site Model

The CSM describes the releases of COPCs that may have occurred, the routes of migration, exposure pathways, and potential receptors. The current understanding of the CSM for human health risks is summarized in Figure 5 and described below. A detailed CSM for ecological risks has not been developed, because ecological risks have been evaluated using a qualitative, screening-level assessment.

4.1 Occurrence and Potential Migration of Chemicals of Potential Concern

The occurrence and migration of COPCs are as follows:

- Historical manufacturing activities and storage of hazardous materials and wastes resulted in releases of COPCs (primarily VOCs) to the ground surface or to subsurface soils. Previous remediation activities, including the DPE/SVE system and excavation addressed soils with the highest VOC concentrations located beneath and immediately to the east of the main manufacturing building (generally above 10 mg/kg of total VOCs). Groundwater remediation has also been conducted that involved *in situ* treatment of groundwater using EZVI in the area east of the main building with the highest concentrations.
- There is no direct evidence of any residual dense non-aqueous phase liquid at the site.
- COPCs in soil could potentially continue to migrate to the groundwater. However, the removal and treatment of soil with the highest VOC concentrations has reduced potential transfer from soil to groundwater, and most of the affected soil is located beneath the building slab or pavement. Concern with leaching from soil to groundwater is also mitigated by the absence of any use of groundwater on the property.
- COPCs in surface soil could potentially be transported to the ambient air due to wind erosion or volatilization, in locations that are not covered by a building or pavement (currently or in the future).
- COPCs dissolved in shallow groundwater will migrate with groundwater flow to the west towards Stony Run.
- COPCs in deep groundwater have migrated off the property to the south-southeast where groundwater is used for potable purposes.
- COPCs in groundwater could potentially migrate into Stony Run, potentially affecting the surface water and sediments; however, the site investigation indicated no effects of the site on surface water or sediments.
- VOCs in shallow groundwater could potentially volatilize, migrate through pores in the overlying soil, and enter buildings through cracks in the foundation (vapor intrusion).

4.2 Receptors

The former Kop-Flex facility was used for manufacturing from 1969 to 2012, when the plant closed. A small number of office employees remain on the property; the office functions will be moved in the next several months. Current potential receptors include facility office workers, visitors, or trespassers.

Facility office workers have no potential for actual exposure to soil or groundwater at the site. Soil impacts are present below the concrete slab in the manufacturing building and present a depth below 10 feet in the area to the east of the manufacturing building; however, the office workers do not access these areas. Visitors that access the office have no potential for exposure to affected soil or groundwater. Similarly, there is no potential for trespassers to contact affected soil or groundwater. These receptors are evaluated in the risk assessment only to address a worst-case scenario (i.e., subsurface soil with the maximum COPC concentrations is brought to the surface). .

The redevelopment plan for the site provides for the construction of a warehouse facility. Two distribution warehouses are planned; one on the north portion of the site and a second on the south portion with a loading dock area separating the buildings and paved surfaces around all buildings. Redevelopment activities will involve construction workers on the property, with excavation of soil expected to a maximum depth of up to 4 feet bgs in the area where loading docks will be constructed. Future use of the property will be commercial, with the associated presence of commercial facility workers inside or outside of buildings. Although not likely with the planned warehouse facility, commercial use generally could also involve the presence of intermittent child or youth visitors. Once the site is redeveloped and mitigation measures implemented, there will be no potential that such workers could contact affected soil below the building slab or groundwater. Institutional controls to prevent residential use of the property or use of groundwater as a source of drinking water will be implemented as part of subsequent remedial measures.

Groundwater containing COPCs at concentrations above RSLs and MDE cleanup standards has migrated off the property to the southwest, Groundwater downgradient of the site is used for drinking purposes. In affected areas, an alternative water source has been provided and a groundwater monitoring network is in place to evaluate trends in water quality.

In summary, the following receptors on the property are considered in the risk assessment:

- Facility workers (indoor and outdoor)
- Child and youth intermittent visitors
- Construction workers

Additional receptors could potentially be affected but are likely to have lesser exposure than the receptors listed above. For example, trespassers would be expected to have less exposure than facility workers. Utility workers may be on the property to conduct short-term installations or repairs and would likely be on the property for a shorter duration than construction workers.

4.3 Exposure Pathways

The presence of COPCs in soil and groundwater could result in the following exposure pathways, assuming a worst-case scenario under which the affected subsurface soil is made accessible (Figure 5):

Exposure to COPCs in soil through the ingestion, dermal contact, or inhalation routes may affect current or future facility workers, intermittent child/ youth visitors, and construction workers.

Inhalation of COPCs originating in soil or groundwater and migrating to indoor air, due to vapor intrusion into buildings, may affect current or future facility workers and intermittent child/youth visitors.

Although vapor intrusion could be a complete exposure pathway under current site conditions, this pathway will be eliminated by engineering controls that are planned as part of site redevelopment. The anticipated controls include a vapor barrier and vapor mitigation system to be installed in future site buildings.

Direct contact with soil by facility workers or intermittent child and youth visitors would be expected to involve only soil near the surface. However, as a conservative, worst-case assumption, potential exposure to all affected soil (to depths up to 15 feet bgs) is considered in the risk assessment.

Pathways involving groundwater are not relevant to the site. Groundwater is not used as a source of drinking water, and institutional controls will ensure that there is no future use of groundwater. The water table occurs at depths of 10 to 15 feet bgs, which is deeper than any foreseeable construction or utility work, so no direct contact with groundwater will occur.

As previously discussed, groundwater containing COPCs has migrated off the property. This results in a potential exposure pathway involving residents who use groundwater as a source of drinking water. However, affected residents have been provided with an alternative water supply.

5 Human Health Risk Assessment

The human health risk assessment (HHRA) involves four components: hazard identification, exposure assessment, toxicity assessment, and risk characterization.

The hazard identification includes the statistical evaluation of the sampling data and the selection of COPCs to be included in the remainder of the risk assessment.

In the exposure assessment, the potential for exposure to COPCs for the potential human receptors identified in the CSM is characterized. Potential exposure pathways are evaluated to determine which, if any, are potentially complete. Next, the exposure point concentrations (EPCs) of COPCs in affected environmental media are calculated, and are used in conjunction with exposure assumptions to determine systemic doses for the applicable potential receptors. Finally, the magnitude, frequency, and duration of these potential exposures are integrated to calculate estimates of daily intakes over a specified exposure period.

The relationship between the potential extent of exposure and the toxicological effects of the exposure is estimated for each COPC in the toxicity assessment. The COPC-specific toxicity criteria are presented, including cancer slope factors (CSFs) or inhalation unit risks (IURs) for carcinogens and reference doses (RfDs) or reference concentrations (RfCs) for non-carcinogens.

Integration of the results of the exposure assessment and the toxicity assessment to derive quantitative estimates of human health risks is accomplished in the risk characterization for carcinogens and non-carcinogens. This component also includes a discussion of the uncertainties and limitations inherent in the estimation of the potential risks, and the potential risks associated with background concentrations.

5.1 Hazard Identification

The purpose of the hazard identification process is to summarize the environmental sampling data and to screen the data to determine the COPCs that will be evaluated further in the risk assessment process. The screening involves comparing representative concentrations in environmental media to conservative values that indicate that risk cannot be ruled out without further analysis. The representative concentrations and the screening levels depend on the environmental medium and exposure pathway under consideration.

Based on the CSM, there are potential complete exposure pathways to human receptors involving contaminants in soil and indoor air. Consumption of groundwater is not anticipated, and groundwater is sufficiently deep to preclude direct contact, so no screening of groundwater sampling data is warranted. Risks associated with the vapor intrusion pathways were evaluated based on soil vapor and indoor air sampling results. Therefore, the hazard identification was conducted based on soil, soil vapor, and indoor air data.

5.1.1 Soil

Evaluation of COPCs in soil incorporated data collected from multiple phases of investigation for each of the AOCs. Appendix A includes tables of sample results and figures showing sample locations from the previous investigations. WSP assembled the following soil data sets:

- Samples collected from 1996 to 1998 during the initial Phase II investigation.
- Samples collected in March 2007 and September 2008 from AOC 1 and AOC 2.
- Samples collected in 2012 and 2013 from AOC 1 and AOC 2.
- Stockpile samples collected in December 2013 and January 2014 during the soil remediation; samples containing less than 1 mg/kg of total VOCs were returned to the excavation and are therefore potentially representative of soil present on the property.

- Samples collected in September 2014 from the loading dock area of the proposed warehouse buildings associated with the future site redevelopment.

The majority of samples were analyzed for VOCs. Samples from the initial Phase II assessment and the 2014 pre-development investigation were also analyzed for semi-volatile organic compounds (SVOCs), PCBs, metals, and cyanide.

For each data set, samples were identified from locations where soil was subsequently removed during the 2013-2014 soil remediation. These samples are not representative of soil remaining on the property and were excluded from the hazard identification. Any sample from a depth greater than 15 feet bgs was also excluded, because no construction, utility repair, or other intrusive activity that could result in contact is reasonably foreseeable at such depths. As a result, the soil data set conservatively includes all samples representative of soil remaining on the property from depths of 0 to 15 feet bgs.

Screening for potential soil direct contact risks was conducted by comparing the maximum detected concentration of a chemical to the Maryland non-residential cleanup standards for soil (Table 1 of MDE 2008) and soil screening values from the EPA Regional Screening Level (RSL; EPA 2015a) tables. The EPA screening values were developed based on conservative assumptions applicable to direct contact with soil at a commercial or industrial facility. The screening values for soil direct contact were based on a hazard quotient (HQ) of 0.1 for non-cancer endpoints and an excess lifetime cancer risk (CR) of 10^{-6} for cancer endpoints. These values are at the low or conservative end of the acceptable range for target risks, but are appropriate for screening, because of the possible effects of multiple chemicals on the risks.

The soil screening results are summarized in Table 1. No VOCs or SVOCs were detected at concentrations above screening levels. PCBs (Aroclor 1260) were detected in one sample at a concentration above the screening levels. Three metals (arsenic, mercury, and thallium) were also detected at concentrations above at least one of the screening levels relevant to a commercial facility. Metal concentrations were also compared to Anticipated Typical Concentrations (ATCs) for eastern Maryland (Appendix 2 of MDE 2008), which are based on measured background levels. The maximum detected thallium concentration was below the ATC, so thallium is not considered a COPC. Arsenic and mercury concentrations exceeded the screening levels and the ATCs. Although there is no known source of arsenic or mercury related to historical facility operations, they were conservatively retained as COPCs.

5.1.2 Soil Vapor and Indoor Air

Soil vapor and indoor air samples were collected in June 2009 (Appendix B), during a period when the DPE and SVE systems were not operating, resulting in data representative of non-remedial conditions. The maximum detected concentrations of VOCs in soil vapor and indoor air were compared to values based on MDE soil vapor and indoor air screening levels for commercial sites (MDE 2012, Table 2). The MDE indoor air screening levels are calculated using a HQ of 1 for non-cancer endpoints and a CR of 10^{-5} for cancer endpoints. The MDE indoor air screening levels were modified to reflect a HQ of 0.1 and CR of 10^{-6}, resulting in more conservative screening levels that are appropriate due to the detection of multiple VOCs in soil vapor and indoor air samples. The soil vapor screening levels are 100 times the indoor air screening levels and are also a factor of 10 lower than the MDE Tier 1 commercial soil gas target levels. This screening process identified one compound (1,2,4-trimethylbenzene) that was detected in an indoor air sample above the screening level. No compounds were detected above the soil vapor screening levels. The soil vapor and indoor air screening evaluation is summarized in Table 2.

5.1.3 Groundwater

COPCs have been detected in groundwater on and off the property at concentrations above MCLs. Groundwater on the property is not used as a source of water, and institutional controls will be implemented to ensure that future use of groundwater does not occur. Offsite properties with COPC concentrations exceeding regulatory limits in drinking water wells have been provided with an alternative water supply, and the sampling of groundwater monitoring wells is currently being conducted to evaluate COPC concentrations in the offsite area. Additional investigation activities will be performed to complete the well network needed to monitor the plume. A groundwater sampling program will then be implemented to evaluate the trends in COPC concentrations in the aquifer system and whether additional actions are warranted to protect the drinking water source in the area.

5.2 Exposure Assessment

The purpose of the exposure assessment is to predict the magnitude and frequency of potential human exposure to each identified COPC as a result of the hazard identification. The CSM (Section 4) describes the potential receptors, media of concern, and complete exposure pathways. Receptors consist of facility workers, construction workers, and intermittent child and youth visitors. Complete exposure pathways consist of soil direct contact by facility and construction workers, and intermittent child and youth visitors, and inhalation of indoor air by facility workers and intermittent child and youth visitors.

5.2.1 Exposure Point Concentration

Medium-specific EPCs were determined using the maximum detected concentration or other measure of reasonable maximum estimate, providing a worst-case evaluation. The EPCs in soil and indoor air were determined for each potential exposure pathway as described below, and are summarized in Table 3.

5.2.1.1 Soil Direct Contact

The screening process identified three COPCs: PCBs, arsenic, and mercury. The EPCs in soil for direct contact pathways were determined using a reasonable maximum estimate of the mean concentration to which a receptor could be exposed. This representative concentration was either the maximum detected concentration among all samples or the 95 percent upper confidence limit of the mean concentration (UL_{95}). The maximum concentration was used for PCBs, which were only detected in samples from one boring.

The UL_{95} was used for arsenic and mercury and was calculated using the EPA's ProUCL 5.0 software (Singh and Singh 2013). The statistical analysis, including input data and the program output with suggested UL_{95} values, is included as Appendix D. Some of the samples had no detection of mercury above the reporting limit. ProUCL included these "non-detect" results in the statistical analysis. The only exception was that for some older non-detect samples, the reporting or detection limit is uncertain, and these samples were not included in the analysis. This would most likely bias the UL_{95} calculation high, although it is believed the remaining samples provide a sufficiently representative measure of mercury concentrations.

5.2.1.2 Indoor Air

EPCs for indoor air for commercial or industrial facility workers and intermittent child or youth intermittent visitors were determined based on indoor air sampling. The maximum concentration detected in indoor air samples was used as the EPC for indoor air. This does not account for engineering controls, including a vapor barrier and vapor mitigation system, which the prospective developer of the property will install in planned commercial buildings.

5.2.1.3 Groundwater

There are no current or future complete exposure pathways for groundwater onsite, because groundwater is not used as a source of water, and institutional controls will be implemented. Similarly, offsite groundwater has been addressed by provision of an alternative water supply and a monitoring program, as appropriate, based on identified impacts to drinking water sources. The proposed response actions call for groundwater extraction and treatment to control migration of affected groundwater from the former Kop-Flex property (WSP 2015), and implementation of a groundwater monitoring plan for the offsite groundwater.

5.2.2 Exposure Assumptions

The evaluation of exposure involves specification of various parameters, including soil ingestion rates, dermal-related values (adherence factor and exposed skin area), exposure frequency and duration, and appropriate time periods over which to calculate average exposure values. The exposure parameters vary by receptor and are listed in Table 4. The majority of the listed values are from recently updated guidance regarding default exposure factors (EPA 2014a). Values for construction workers, which are not addressed in the 2014 guidance, were obtained from the EPA soil screening guidance (EPA 2002b) or from the Risk Assessment Guidance for Superfund supplement on dermal risk assessment (EPA 2004b). The construction worker exposure factors are the same as those provided in the EPA RSL User's Guide (EPA 2014b).

5.2.3 Exposure Calculations

Depending on the route, exposure is measured as an intake rate (ingestion), an absorbed dose (dermal), or an exposure concentration (inhalation). The exposure calculations are presented in Tables E-1 through E-4 of Appendix E. The exposure to COPCs is calculated using the following formulas:

Soil ingestion intake (mg/kg-d) = $EPC_{soil} \times 10^{-6} \times EF \times ED \times IR_{soil}/(BW \times AP)$

Soil dermal absorbed dose (mg/kg-d) = $EPC_{soil} \times 10^{-6} \times ABS_d \times SA \times AF \times EV \times EF \times ED / (BW \times AP)$

Soil inhalation exposure concentration (particulates; mg/m^3) = $EPC_{soil} \times (1/PEF) \times ET \times EF \times ED / (AP \times 24)$

Soil inhalation exposure concentration (volatiles; mg/m^3) = $EPC_{soil} \times (1/VF) \times ET \times EF \times ED / (AP \times 24)$

Air inhalation exposure concentration (mg/m^3) = $EPC_{air} \times ET \times EF \times ED / (AP \times 24)$

Where:

EPC_{soil} = exposure point concentration in soil (mg/kg)

EPC_{air} = exposure point concentration in air (mg/m^3)

ET = exposure time for air (hours/day)

EV = event frequency (events/day)

EF = exposure frequency for soil contact or air inhalation (days/year)

ED = exposure duration (years)

IR_{soil} = soil ingestion rate (mg/day)

BW = body weight (kg)

AP = averaging period (days); separate values apply to non-cancer and cancer risk calculations

ABS_d = dermal absorption fraction

SA = exposed surface area for soil exposure (cm^2)

AF = dermal adherence factor for soil (mg/cm^2-event)

PEF = particulate emission factor (m^3/kg); see below

VF = volatilization factor (m^3/kg); see below

PEF is the ratio of COPC concentrations in soil and air (due to particulate releases) and is a parameter in the inhalation exposure calculation. This factor may vary depending on assumptions related to vegetative cover, wind, and site activities. We have assumed a single value, 1.36×10^9 m^3/kg, for all exposure scenarios. This is the default value from the EPA soil screening guidance (EPA 1996), which accounts for wind erosion of soil at the surface on a 0.5-acre site under typical meteorological conditions. Other values may result from alternative assumptions, but in any case, particulate inhalation was found to have a negligible contribution to risk relative to the other exposure routes for the COPCs on this site.

VF is similarly the ratio of COPC concentrations in soil and air (due to volatilization). This factor is relevant to one of the soil COPCs (mercury) that is potentially volatile under normal conditions. This is a chemical-specific parameter and is calculated using the following equations (EPA 2002a):

$VF = (Q/C_{vol}) \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4} / (2 \times \rho_b \times D_A)$

$VF_{sc} = (Q/C_{sa}) \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4} / (2 \times \rho_b \times D_A \times F_D)$

$D_A = (\theta_a^{10/3} D_i H + \theta_w^{10/3} D_w) / [n^2(\rho_b K_d + \theta_w + \theta_a H)]$

Where:

VF = volatilization factor (m^3/kg)
VF_{sc} = volatilization factor for sub-chronic exposure (e.g., construction worker scenario; m^3/kg)

D_A = apparent diffusivity (cm^2/s)

Q/C_{vol} = ratio of volatilization flux to geometric mean air concentration at center of affected area (g/m^2-s per kg/m^3)

Q/C_{sa} = ratio of volatilization flux to geometric mean air concentration at center of affected area, for sub-chronic exposure (g/m^2-s per kg/m^3)

T = exposure interval (s)

ρ_b = dry bulk density (g/cm^3)

θ_a = air-filled porosity (unitless)

θ_w = water-filled porosity (unitless)

n = total porosity (unitless)

D_i = diffusivity in air (cm^2/s)

D_w = diffusivity in water (cm^2/s)

H = Henry’s law constant (unitless)

K_d = soil/water partition partition coefficient (cm^3/g)

The parameter values and calculations of VF are summarized in Table 5. The soil properties (ρ_b, θ_a, θ_w, and n) are default values from EPA 2002b. The values of Q/C_{vol} and Q/C_{sa} are default values from EPA 2002b that are based on dispersion modeling and assume a 0.5-acre site. The exposure interval is assumed to be 25 years for chronic and 1 year for sub-chronic calculations. Chemical-specific parameters (D_i, D_w, H, and K_d) were obtained from the RSL table (EPA 2015a) and apply to elemental mercury.

5.3 Toxicity Assessment

The purpose of the toxicity assessment is to determine the relationship between the dose of a constituent taken into the body, and the probability that an adverse effect will result from that dose. Toxicity information was obtained from information sources according to the EPA hierarchy of toxicity values (EPA 2003). Tier 1 of the EPA hierarchy consists of toxicity values from the latest version of the Integrated Risk Information System (IRIS; EPA 2015b). Tier 2 toxicity values include the Provisional Peer Reviewed Toxicity Values from the National Center for Environmental Assessment/Superfund Health Risk Technical Support Center. Tier 3 toxicity values consist of other EPA and non-EPA values, including California Environmental Protection Agency (Cal EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs; ATSDR 2013), and the EPA Health Effects Assessment Summary Tables.

Quantitative estimates of the potency of COPCs include two sets of toxicity values, one for carcinogenic effects and one for non-carcinogenic effects. For carcinogenic effects, EPA uses a dose-response model with a non-threshold toxicological mechanism, with a probability of an adverse effect from any dose above zero. Toxicity criteria for non-carcinogens assume that there is a threshold effects level, below which adverse health effects are not expected to occur.

The toxicity values for each COPC are summarized in Table 6. Selection of values related to carcinogenic effects and non-cancer hazards is discussed below.

5.3.1 Carcinogenic Effects

For carcinogenic effects, EPA assigns a weight-of-evidence descriptor to each COPC, and then, if applicable, a CSF or IUR is calculated. The weight-of-evidence descriptor is based on the likelihood that the COPC is a human carcinogen. The following are the weight-of-evidence descriptors:

- Carcinogenic to humans – convincing epidemiologic evidence demonstrating causality between human exposure and cancer, or exceptionally when there is strong epidemiological evidence, extensive animal evidence, knowledge of the mode of action, and information that the mode of action is anticipated to occur in humans and progress to tumors.
- Likely to be carcinogenic to humans – available tumor effects and other key data are adequate to demonstrate carcinogenic potential to humans, but does not reach the weight-of-evidence for the descriptor of carcinogenic to humans.
- Suggestive evidence of carcinogenic potential – evidence from human or animal data is suggestive of carcinogenicity, which raises a concern for carcinogenic effects but is judged not sufficient for a stronger conclusion.
- Inadequate information to assess carcinogenic potential – available data is judged inadequate to perform an assessment.
- Not likely to be carcinogenic to humans – available data are robust for deciding that there is no basis for human hazard concern.

EPA determines CSFs for oral exposure and IURs for inhalation exposure for those chemicals that are known or likely human carcinogens. The CSFs and IURs are upper-bound estimates of the excess cancer risk due to continuous exposure to a COPC averaged throughout the course of a lifetime. The CSF is the excess lifetime cancer risk associated with a unit dose by the oral route and has units of $(\text{mg/kg-day})^{-1}$. An IUR is the risk through the inhalation route associated with a unit concentration in air and has units of $(\text{mg/ m}^3)^{-1}$. The basis of CSFs and IURs are data from lifetime animal bioassays, although human data are used when available.

Risks involving dermal exposure are evaluated using the oral CSF. The oral CSF may be adjusted for some COPCs to account for a gastro-intestinal absorption factor significantly less than 1. This adjustment is needed, because toxicity studies are based on the quantity of a chemical that is ingested, without consideration of the proportion that is actually absorbed, while dermal risk calculations are based on the quantity of the COPC absorbed. However, such an adjustment was not warranted for arsenic or PCBs (the only soil COPCs with oral CSF values).

5.3.2 Non-Carcinogenic Effects

Non-carcinogenic effects, such as organ damage or reproductive effects, are evaluated by RfDs for oral exposure, or RfCs for inhalation exposure. The basis of a chronic RfD or RfC calculation is usually the highest dose that results in a no observed adverse effect level (NOAEL) after chronic (usually lifetime) exposure in animal experiments. The NOAEL is then divided by a safety factor, and occasionally an additional modifying factor, to obtain the RfD or RfC. Uncertainty factors are typically factors of 10 that account for interspecies variation and sensitive human populations. Additional factors of 10 are included in the uncertainty factor if the RfD or RfC is based on the lowest observed adverse effect level (LOAEL) instead of the NOAEL, or an experiment that includes a less-than-lifetime exposure. The oral RfD was also used for the dermal route, since the gastro-intestinal absorption factor is not significantly less than 1 for any of the COPCs.

One of the receptors evaluated, the construction worker, is assumed to have an exposure duration (1 year) that is relatively short-term or sub-chronic, while the facility worker has long-term or chronic exposure. In some cases, the RfD or RfC for sub-chronic exposure may be higher than for chronic exposure. For example, IRIS may indicate that a sub-chronic-to-chronic extrapolation factor (typically 3 or 10) was applied to reduce the RfD or RfC, in cases where the toxicity studies were conducted over short periods of time, to reflect uncertainty associated with extrapolation to chronic time periods. In these cases, the chronic RfD or RfC value published in IRIS is multiplied by the extrapolation factor to yield the sub-chronic RfD or RfC.

5.4 Risk Characterization

The purpose of the risk characterization is to provide a conservative estimate of the potential risk resulting from exposure to COPCs identified in environmental media. Included in this section is a quantitative estimate of potential carcinogenic and non-carcinogenic risks for each complete exposure pathway for each receptor. The risk characterization follows state and federal guidance including MDE (2006) and EPA (1989). Detailed risk calculations for each receptor and exposure scenario are presented in Appendix E.

For a given receptor, the non-cancer HQ and excess lifetime CR were calculated for each source medium, exposure medium, exposure point, exposure route, and COPC. For example, releases to soil result in potential exposure of receptors (facility worker or construction worker) through up to three routes of exposure (ingestion, dermal absorption, and inhalation of particles and vapors). The HQ values were added across all relevant pathways for each receptor to determine an overall hazard index (HI). Similar, the CR values were added across pathways to determine a total CR.

The HQ for each relevant exposure route and COPC was calculated as follows:

HQ = Intake / RfD (ingestion route)

HQ = Dermal Absorbed Dose / RfD (dermal route)

HQ = Exposure Concentration / RfC (inhalation route)

A HQ was calculated for each pathway and each COPC affecting a receptor, and the individual HQs were summed for an overall HI. If the HI is less than 1, then no adverse health effects are likely associated with exposures at the facility. However, if the total HI is greater than 1, separate endpoint-specific HIs may be calculated based on target organs (e.g., HQs for neurotoxins are summed separately from HQs for renal toxins). Only if a target-organ-specific HI is greater than 1 is there a reason for concern about potential health effects for that target organ.

The CR was calculated as follows:

CR = Intake x CSF (ingestion route)

CR = Dermal Absorbed Dose x CSF (dermal route)

CR = Exposure Concentration x IUR (inhalation route)

In the case of arsenic, the HQ and CR values for the ingestion route were further adjusted to account for relative bioavailability (RBA), with multiplication of the HQ and CR values defined above by 0.6. This factor represents a conservative estimate of the absorbed proportion of arsenic in soil relative to arsenic in water. The RBA is applied due to the fact that the toxicity studies for arsenic used as a basis for the oral toxicity values (RfD and CSF) in IRIS involved ingestion of arsenic in drinking water. Based on various studies that have determined estimates of the RBA for arsenic, a default value of 0.6 has been recommended (EPA 2012).

Non-cancer HI and CR values were calculated for each receptor, including facility workers, construction workers, child intermittent visitors, and youth intermittent visitors. The calculations were made assuming future adoption of the following types of institutional controls for the property:

- restricting the property to commercial use and prohibiting residential or other uses (such as schools or day care centers) involving the frequent presence of children
- prohibiting use of groundwater on the property

These controls would be warranted, because the risk characterization has assumed no residential use and no use of groundwater as a source of potable water.

The results of the risk characterization are summarized in Table 7. The HI for each receptor is compared to a target value of 1. The CR is compared to a target value of 1×10^{-5}. These target values correspond to the MDE remedial action standards (MDE 2008). The cumulative HI and CR do not exceed the target values.

The results of the risk characterization indicate both current and future site conditions do not pose significant human health risks to workers or visitors. Due to the assumptions regarding future uses and activities associated with the property, institutional controls are warranted to prevent residential use and groundwater consumption. Furthermore, the evaluation of vapor intrusion risks was specific to the current facility building, because it relied on soil vapor and indoor air sampling results from that building. In the event that a different building is constructed in the future (e.g., at a different location on the property or with different size or other characteristics), further evaluation of potential vapor intrusion risks or implementation of engineering controls to prevent vapor intrusion would be warranted.

Risks associated with consumption of groundwater onsite or offsite have not been evaluated quantitatively. Onsite groundwater is not used as a source of drinking water and will be addressed by a planned institutional control. In offsite locations where COPC concentrations exceed MCLs, an alternative water supply has been provided, and a groundwater monitoring network is in place.

5.5 Uncertainty

The procedures and inputs used to assess potential human health risks in this and similar risk assessments are subject to a wide variety of uncertainties. In general, there are four main sources of uncertainty and variability in risk assessments of well-characterized sites:

- environmental chemistry sampling and analysis
- receptor exposure profiles and dose-exposure assumptions
- fate and transport modeling of exposure point concentrations
- toxicological data and dose-response extrapolations

Variability in environmental chemistry sampling and analysis error can stem from the sampling and analysis procedures, and from the heterogeneity of the matrix being sampled. Changes in the types of soil, total organic carbon content, and grain size can affect the percent recovery of chemicals from soil samples, which in turn changes the reported concentration of the chemicals detected in the sample. Natural sample variability, typically following a log-normal distribution, is also expected.

One method of addressing uncertainty regarding representative soil concentrations has been to use conservative estimates of the concentrations in soil, such as the maximum or UL_{95} values. In the case of soil vapor and indoor air sampling, it is possible that the available data are not conservative, because only one sampling event occurred, and VOC concentrations in soil vapor and indoor air can be highly variable. The results are also influenced by the particular characteristics of the existing building, and might not necessarily apply to future buildings. Uncertainty associated with vapor intrusion will be addressed by institutional or engineering controls.

Exposure estimation is another potential source of variability and uncertainty. Exposure estimates in many cases are highly dependent on the prediction of intake values, exposure frequency, exposure duration, and other exposure assumptions used in the assessment. Consistent with EPA and MDE guidance, the exposure parameters used in this risk assessment were very conservative and selected to ensure that potential exposure was not underestimated. However, actual exposure would likely be considerably less than the estimates contained in this risk assessment.

The results of animal studies are used to predict the potential health effects of chemicals in humans. Extrapolation of toxicological data from animal tests is a large source of uncertainty in any risk assessment. There may be important but unidentified differences in uptake, metabolism, and distribution in the body between the test species and humans. Typically, the animals are administered high doses of a chemical in a standard diet while humans are generally exposed to much lower doses in a highly variable diet. Humans typically have a 70-year lifetime and may be exposed intermittently for an exposure period ranging from months to a full lifetime. Because of these differences, extrapolation error is a large source of uncertainty in risk assessment. Even when epidemiological studies in humans are available, uncertainties can be large because the diet, activity patterns, exposure duration and frequency, and individual susceptibility may not be the same in the study populations as in the site-specific receptors.

Uncertainties from different sources are compounded in the risk assessment. For example, if a chronic daily intake for a contaminant measured in the environment is compared to an RfD to determine potential health hazard, the uncertainties in the concentration measurement, exposure assumptions, and the toxicology are all expressed in the result. In order to ensure that human health is adequately protected, the public health assessment incorporates conservative (unlikely to underestimate risk) approaches and uncertainty factors. Therefore, the actual risk associated with the property is unlikely to be larger than the risk predicted in this assessment.

6 Screening-Level Ecological Risk Assessment

An ERA evaluates the potential for adverse ecological effects to occur as a result of exposure to one or more anthropogenic stressors. The objective of an ERA is to assess the risk of harm to habitats and biota exposed to COPCs at or from a disposal site.

EPA guidance (EPA 1997) suggests elements for an initial or screening-level assessment of ecological risks. First, the environmental setting and COPCs are identified. Fate and transport of COPCs from sources to other locations on or off the property are evaluated. Ecological receptors, potential toxicity of the COPCs to these receptors, and complete exposure pathways are evaluated. During this process, exposure pathways are eliminated from further evaluation if they are unlikely to result in environmental harm. If complete exposure pathways are identified, potential adverse effects on receptors are evaluated based on comparison to appropriate ecological benchmarks or screening levels, which provide a conservative measure of toxicity. If warranted, a more comprehensive assessment of exposures and resulting risks may be proposed.

The current screening-level ERA follows the EPA guidance (EPA 1997) and evaluates potential exposure pathways based on the environmental setting and investigation results discussed in previous sections of this report. Terrestrial and freshwater aquatic environments are considered. Concentrations of COPCs are then compared to applicable screening levels.

6.1 Problem Formulation

Problem formulation, as described in the EPA guidance, involves developing a preliminary CSM consisting of the following elements:

- Environmental setting and COPCs
- Fate and transport of COPCs
- Potential receptors and eco-toxicity
- Potential complete exposure pathways
- Selection of endpoints to screen for ecological risk

6.1.1 Environmental Setting and COPCs

Details on the environmental setting were presented in Section 2.2. In summary, the former Kop-Flex property has an elevation of approximately 125 feet AMSL. The site is underlain by an upper sand unit to a typical depth of 10 feet bgs, which is believed to be mostly fill material. The upper sand unit is underlain by a middle unit consisting of predominantly fine-grained sediments (silt and clay), with occasional sand zones. A lower unit consists primarily of sand and gravelly sand deposits with rare, discontinuous layers of sandy to clayey silt sediments.

Shallow groundwater occurs in the upper sand beginning at a depth of generally 10-15 feet bgs. Groundwater in the upper and middle units is unconfined and flows to the west and northwest, eventually discharging into Stony Run. The dense clay deposits in the lower portion of the middle unit form a confining unit. Beneath this unit is the confined groundwater of the Lower Patapsco Aquifer. Groundwater flow in this unit is to the south-southeast.

The closest body of surface water is Stony Run, which crosses the western portion of the site. The 100-year flood plain of Stony Run includes a portion of the parking lot northwest of the main building. Stony Run flows north across Dorsey Road, located approximately 2,000 feet north of the Kop-Flex property, through the Baltimore Commons Business Park and Patapsco State Park before discharging into the Patapsco River, 7 miles to the north. Wetlands (other than areas along Stony Run) are not present on the former Kop-Flex property.

As described in detail in previous sections of this report, releases to the soil have occurred, notably in AOC 1 and AOC 2, located within and immediately to the east of the main manufacturing building. Soil containing the highest

VOC concentrations beneath and immediately to the east of the main manufacturing building was removed during the remedial action in 2013 and 2014. The soil remaining on the site has lower concentrations of VOCs and other chemicals that do not pose a significant risk to human health.

Soil containing COPCs is located predominantly beneath or to the east of the main manufacturing building. Based on current and planned future development, the property in general consists of areas covered by buildings, paved parking lots and roadways, and grass or other landscaping. Releases to soil on the property have not occurred in locations that serve as a habitat for terrestrial plants and animals. With both the current facility and the planned development, the affected soil is predominantly beneath buildings and pavement.

Groundwater beneath the property contains VOCs. However, given the depth to groundwater (typically 10-15 feet bgs), exposure to groundwater by ecological receptors does not occur.

Surface water and sediment samples collected on or upstream of the property have contained low concentrations of some chemicals. In many cases, the concentrations of upstream and on-property samples were similar, indicating no apparent effects associated with the former Kop-Flex property. The chemicals detected in surface water and sediment samples do not include the main COPCs for soil and groundwater in AOC 1 and AOC 2 (i.e., TCA and other chlorinated compounds).

6.1.2 Fate and Transport of COPCs

COPCs in soil could potentially continue to migrate to the groundwater. Due to the removal of soil with the highest VOC concentrations during previous remedial activities, infiltration of water through the soil remaining at the site is expected to result in minimal transport of COPCs to the groundwater system.

COPCs in the shallow groundwater zone will migrate with groundwater flow to the west or northwest and discharge into Stony Run. Another potential transport mechanism that could affect the stream is erosion of surface soil containing COPCs. However, the main soil and groundwater COPCs (e.g., TCA and other chlorinated VOCs) have not been detected in surface water samples.

6.1.3 Potential Receptors and Eco-toxicity

Detailed data on receptors in Stony Run has not been collected. The stream and sediments could potentially serve as a habitat for freshwater aquatic plants, macro-invertebrates, fish, or other types of aquatic species. A detailed evaluation of eco-toxicity has not been conducted for this screening-level ERA. The main COPCs present on the site (e.g., TCA and other chlorinated VOCs) have a low potential for bio-concentration.

COPCs in soil occur beneath or immediately adjacent to the plant building. No terrestrial ecological receptors have been identified in these areas.

6.1.4 Potential Complete Exposure Pathways

The transport of COPCs dissolved in groundwater into Stony Run and its sediments could result in a complete exposure pathway involving aquatic organisms, such as benthic macro-invertebrates or fish present in the stream. Wildlife using the stream or its banks as a source of food and water or as habitat, such as reptiles, amphibians, birds, and mammals, could also potentially be exposed to any COPCs that reach the stream.

In the affected areas, there is minimal terrestrial habitat that would be used as a foraging or breeding area for ecological receptors. Therefore, the terrestrial soil exposure pathway is not considered complete.

6.1.5 Assessment Endpoints

In an ERA, receptors are classified as an organism, group of organisms, or a specific habitat affected by COPCs. Receptors potentially at risk depend upon the existing habitat, or what would exist in the absence of the site, the distribution of COPCs, and the susceptibility of the organisms to the COPCs related to the Site. Receptors that could serve as endpoints include individual organisms of endangered species, subpopulations, populations, communities, and habitats. In this screening-level ERA, assessment of effects on aquatic receptors will be conducted based on a comparison to available screening levels, as discussed below.

6.2 Effects-Based Screening for Aquatic Exposure Pathways

A complete exposure pathway has been identified for organisms living in or otherwise contacting water or sediments in Stony Run, or using such organisms as a food supply. Preliminary evaluation of potential effects of COPCs on ecological receptors was conducted based on comparison of concentrations detected in surface water and sediment samples to screening levels. Any compound detected in at least one surface water or sediment sample was included as a COPC for purposes of the screening. As suggested in MDE guidance (MDE 2008), the screening used relevant standards or eco-toxicological benchmarks.

Surface water samples were collected at two upstream locations and one downstream location in October 1998 and analyzed for VOCs, SVOCs, and inorganics (metals and cyanide). No VOCs were detected. Additional surface water samples were collected in 2001 and analyzed for VOCs, with none detected. The maximum detected concentrations of SVOCs and inorganics from the 1998 sampling event were compared to the following ecological screening levels (Table 8):

- Maryland Numerical Criteria for Toxic Substances in Surface Water (COMAR 26.08.02.03-02), chronic freshwater values for aquatic life
- EPA National Recommended Water Quality Criteria, chronic values for aquatic life (EPA 2014c)
- The downstream sample from October 1998 contained an iron concentration higher than the upstream samples and slightly above the screening levels. There is no indication that activities at the site would result in a significant release of iron to groundwater that discharges to surface water. Moreover, the facility complied with applicable regulations related to storm water discharges, and water quality in Stony Run (even at the "downstream" sample station) could potentially be affected by runoff from multiple properties. Therefore, the slightly elevated iron concentration is not considered to be an indication of potential ecological risk related to the site. No other inorganic parameters or organic compounds were detected at a concentration above the screening levels. The concentrations in surface water also did not exceed EPA recommended criteria for human health based on consumption of water and aquatic organisms; the manganese concentration exceeded a secondary maximum contaminant level based on non-health considerations such as taste.

Sediment samples were collected at two upstream locations and one downstream location in October 1998 and analyzed for VOCs, SVOCs, and inorganics. No SVOCs were detected. The maximum detected concentrations of VOCs and inorganics were compared to the following ecological screening levels (Table 9):

- EPA Region 3 Freshwater Sediment Screening Benchmarks (EPA 2006).
- Threshold effects levels (TELs) or similar benchmarks obtained from the National Oceanic and Atmospheric Administration Screening Quick Reference Tables (SQuiRT; Buchman 2008).

The carbon disulfide concentration in an upstream sample exceeded a screening level. This compound was not detected in the downstream sample and is not associated with the former Kop-Flex site. Total cyanide concentrations in all samples exceeded a screening level for free cyanide. However, the cyanide concentrations were similar in the upstream and downstream samples, indicating no apparent association with the site. Therefore, the sediment sampling results do not indicate potential ecological risk associated with the site.

6.3 Ecological Screening Conclusions

The screening-level ERA did not identify any complete exposure pathways involving terrestrial receptors. Low levels of COPCs remain in subsurface soil beneath the main plant building and adjacent areas of the property. These locations do not serve as a habitat for significant populations of terrestrial organisms, either under the current configuration of the property or the planned site development. Therefore, further evaluation of terrestrial receptors is not warranted.

Potential complete pathways involving exposure of aquatic receptors to COPCs in surface water and sediments were identified. Shallow groundwater flows from the former Kop-Flex facility towards Stony Run, a potential habitat for freshwater aquatic organisms. Chemicals that were released to soil and groundwater, including chlorinated VOCs, were not detected in surface water and sediment samples collected from this stream. All surface water and sediment sampling data were screened against relevant ecological benchmarks. One downstream surface water sample contained an iron concentration exceeding the upstream concentrations and also slightly above the screening levels. There is no indication of significant releases of iron associated with facility operations, and other chemicals did not exceed screening levels or were present at similar concentrations in upstream and downstream samples. Therefore, the screening-level ERA does not indicate potential adverse effects on aquatic organisms.

7 Conclusions

The following conclusions are drawn from the SSRA for the former Kop-Flex site:

- Previous investigations have identified releases of COPCs, predominantly chlorinated VOCs, to soil and groundwater. The presence of these COPCs in environmental media is associated with historical releases of hazardous materials to the soil, transport through the soil to groundwater, and migration of affected groundwater through unconsolidated, transmissive zones, and volatilization from the groundwater surface. The affected soil area includes the former main manufacturing building at the site and area to the east of the building.
- The property was occupied by a manufacturing facility. Future uses of the property are expected to be commercial, with current redevelopment plans to involve a warehouse facility.
- Concentrations of certain COPCs in soil and indoor air samples exceeded relevant human health screening levels for a commercial property. COPCs for soil consist of PCBs, arsenic, and mercury. COPCs for indoor air consist of 1,2,4-trimethylbenzene.

Based on conservative, worst-case assumptions, human receptors that could potentially be exposed to the COPCs include current and future facility workers, future construction workers, and current and future child and youth visitors. Complete exposure pathways include direct contact with soil by a facility or construction worker or child or youth visitor, and inhalation by facility workers or child or youth visitors of COPCs in indoor air due to vapor intrusion. Because groundwater is not and will not be used as a source of drinking water, and the depth to groundwater is generally 10 to 15 feet bgs, no complete exposure pathways involving groundwater were identified.

Soil EPCs were calculated based on the maximum or UL_{95} concentrations of COPCs. Concentrations in indoor air were determined based on the maximum detected concentration.. Measures of exposure were then calculated using standard EPA default exposure factors and equations drawn from EPA guidance.

Measures of toxicity and cancer risk associated with COPCs were determined from IRIS or other sources, based on the EPA hierarchy.

The non-cancer hazard index and cancer risk were calculated for each receptor using standard EPA methodology. The risks to a facility worker or construction worker would be below the target values, indicating acceptable risk under current and foreseeable site conditions.

The risks associated with vapor intrusion are uncertain, because they are based on one round of soil vapor and indoor air sampling. Furthermore, the risk characterization applies to the current building but might not reflect conditions associated with future buildings. Therefore, engineering controls, institutional controls, or further evaluation of vapor intrusion risks may be warranted in conjunction with construction of future buildings. Installation of vapor barriers and vapor mitigation systems are planned as part of future site development.

Due to the assumptions incorporated in the risk assessment, institutional controls on the property are warranted. These controls would prevent residential or other special uses of the property and use of groundwater as a source of drinking water.

A screening-level ERA was conducted, to identify potential risks to ecological receptors. Potential complete exposure pathways were found to exist for freshwater aquatic organisms in Stony Run, which flows through the west side of the former Kop-Flex property. No complete exposure pathways were identified for terrestrial receptors, because COPCs in surface soil are limited to developed portions of the property that do not serve as potential habitat.

Concentrations of COPCs in surface water and sediment were compared to relevant ecological screening levels. The maximum COPC concentrations are below screening levels, similar in upstream and downstream samples, or not likely to be related to activities on the former Kop-Flex property. As a result, potential adverse effects on aquatic receptors have not been identified.

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9 Acronym List

AMSL	above mean sea level
AOC	area of concern
ATC	anticipated typical concentration
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
CSF	cancer slope factors
COPC	chemical of potential concern
CR	cancer risk
CSF	cancer slope factor
CSM	conceptual site model
DCA	dichloroethane
DCE	dichloroethane
DPE	dual-phase extraction
ESC	Environmental Strategies Corporation
EPA	Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
EZVI	emulsified zero-valent iron
ft	feet
HHRA	human health risk assessment
HQ	hazard quotient
HI	hazard index
IUR	inhalation unit risk
LOAEL	lowest observed adverse effect level
MDE	Maryland Department of the Environment
MRL	minimum risk level
NPDES	National Pollution Discharge Elimination System
NOAEL	no observed adverse effect level
PCBs	polychlorinated biphenyls
RAGS	Risk Assessment Guide to Superfund
RBA	relative bioavailability
RfC	reference concentration
RfD	reference dose

RSL	Regional Screening Level
SQuiRT	Screening Quick Reference Tables
SSRA	site-specific risk assessment
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TCA	1,1,1-trichloroethane
TEL	threshold effects level
UL_{95}	95 percent upper confidence limit of the mean
UVB	Unterdruck-Verdampfer-Brunnen
VCP	Voluntary Cleanup Program
VOC	volatile organic compound

Figures

DWG Name:

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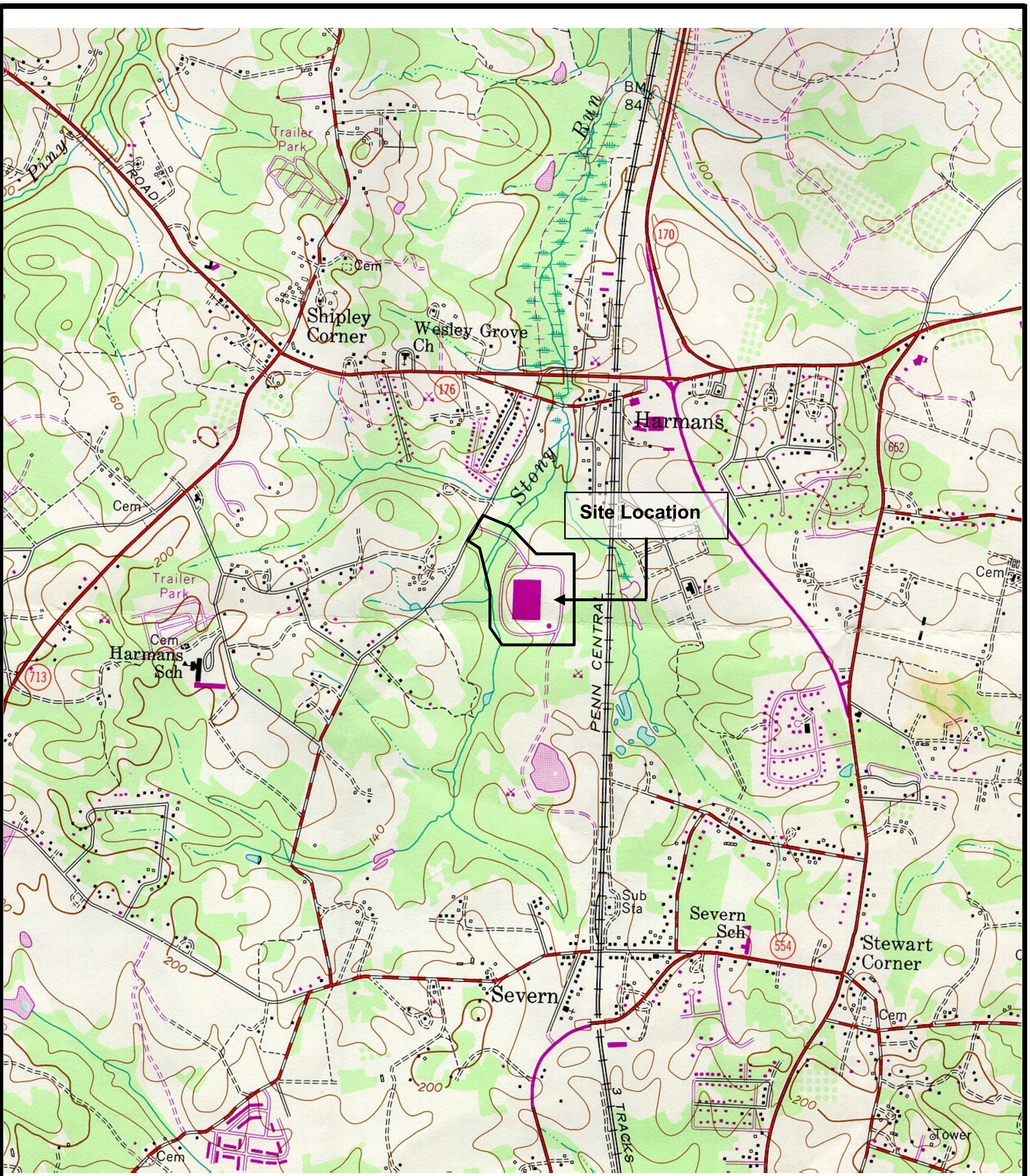

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7.5 MINUTE SERIES TOPOGRAPHIC QUADRANGLE
RELAY, MARYLAND
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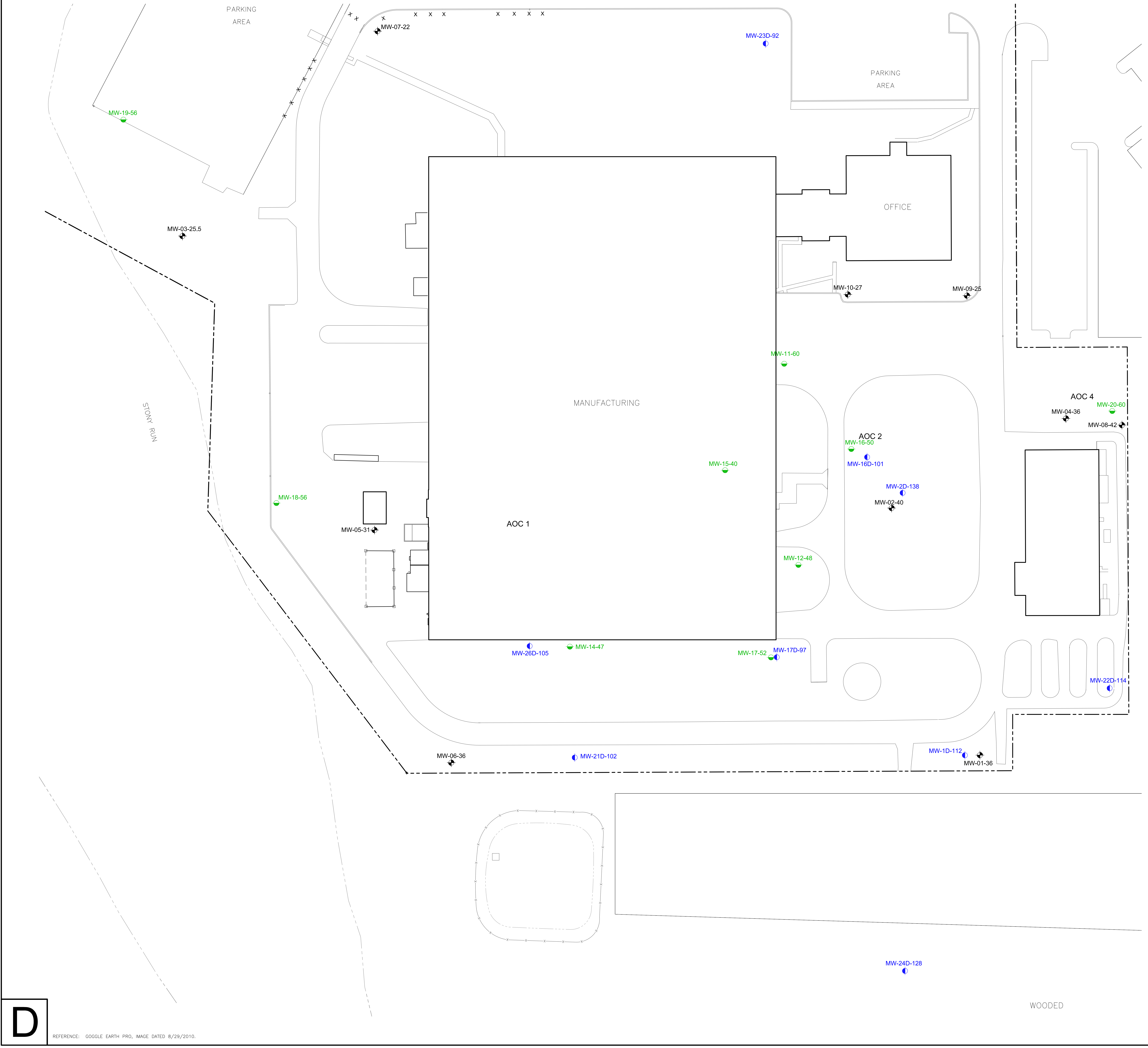
FIGURE 1

SITE LOCATION MAP

KOP-FLEX
HANOVER, MARYLAND

PREPARED FOR

EMERSON
ST. LOUIS, MISSOURI



LEGEND

- ⊕ SHALLOW MONITORING WELL LOCATION
- ⊖ INTERMEDIATE MONITORING WELL LOCATION
- ◐ DEEP MONITORING WELL LOCATION

MW-2D-138
WELL DEPTH
WELL ID

NOTES:

1. UNTERDRUCK–VERDAMPFER–BRUNNEN (UVB) WELLS WERE INSTALLED BETWEEN APRIL 1999 AND MARCH 2001 AS PART OF THE RESPONSE ACTION PLAN FOR AREAS 2 AND 4.
2. DUAL PHASE EXTRACTION (DPE) AND SOIL VAPOR EXTRACTION (SVE) WELLS WERE INSTALLED IN APRIL 2002 AS PART OF THE RESPONSE ACTION PLAN FOR AREA 1.
3. SAMPLE LOCATIONS DENOTED WITH "WP–" WERE COMPLETED IN AUGUST 2006 AS PART OF A GROUNDWATER INVESTIGATION IN AREA 2 AND 4 USING A WATERLOO GROUNDWATER PROFILER.
4. SAMPLE LOCATIONS DENOTED WITH "SSI–" WERE COMPLETED IN MARCH 2007 TO INVESTIGATE THE STORM SEWER IN AREA 2.
5. SAMPLE LOCATIONS DENOTED WITH "WSP–" WERE COMPLETED IN AUGUST 2007 TO INVESTIGATE SOIL AND GROUNDWATER QUALITY IN AREA 2.

N

0 50 100 150
SCALE IN FEET

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REFERENCE: GOOGLE EARTH PRO, IMAGE DATED 8/29/2010.

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REVISIONS

REV	DESCRIPTION		
		Revised:	Chkd:
		Revised:	Chkd:
		Revised:	Chkd:

Appr.:

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DATE

DRAWN BY	EGC
CHECKED	RG 10/19/2012
APPROVED	KG 5/3/2013

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SITE LAYOUT WITH GROUNDWATER MONITORING WELLS

KOP–FLEX
HANOVER, MARYLAND
PREPARED FOR
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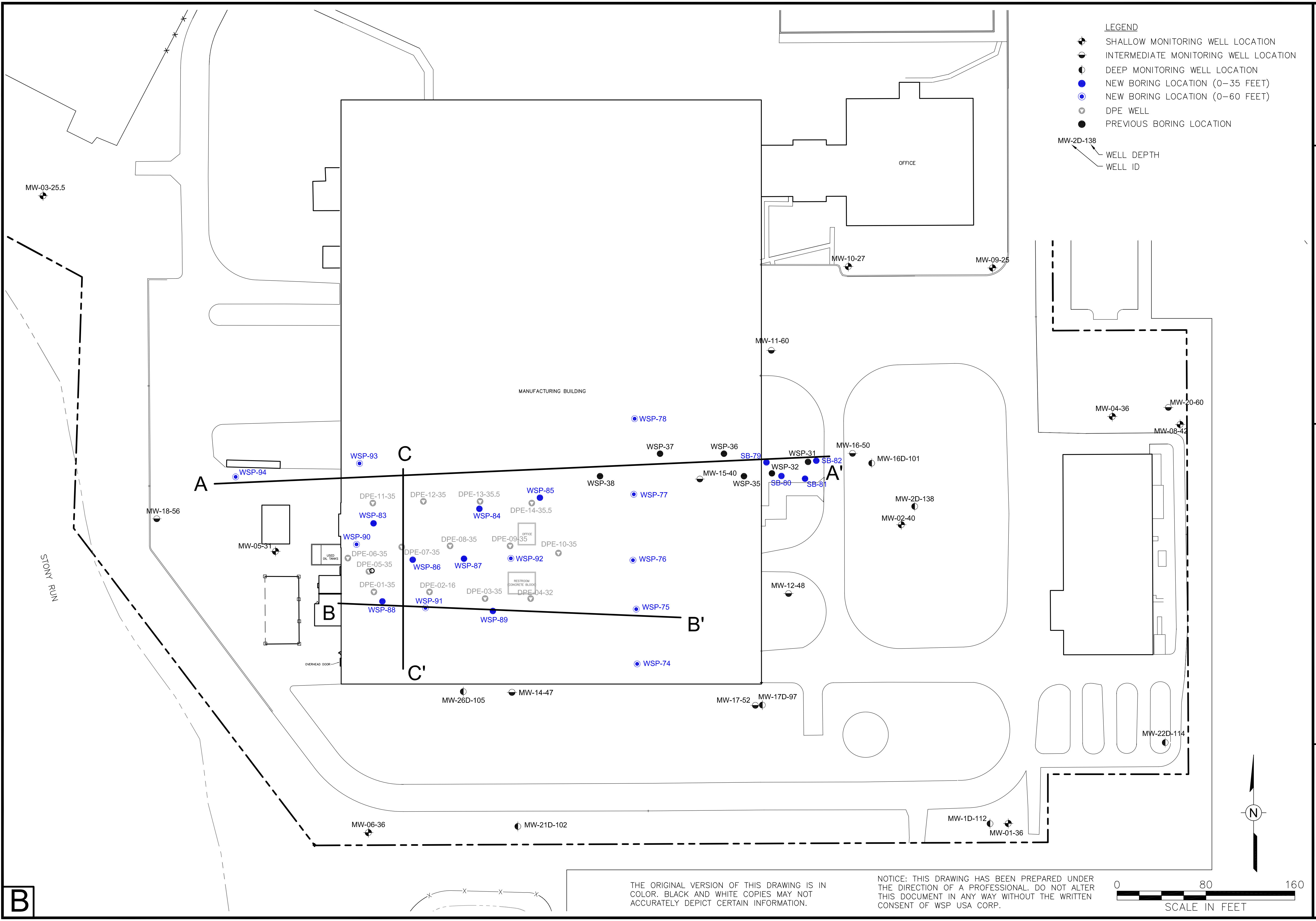
FIGURE 2

Drawing Number
00003705–109



LEGEND

- ⊕ SHALLOW MONITORING WELL LOCATION
- ⊖ INTERMEDIATE MONITORING WELL LOCATION
- ◐ DEEP MONITORING WELL LOCATION
- ● NEW BORING LOCATION (0–35 FEET)
- ◉ NEW BORING LOCATION (0–60 FEET)
- ▽ DPE WELL
- ● PREVIOUS BORING LOCATION

MW-2D-138
WELL DEPTH
WELL ID

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Approved: KG 5/6/2013
DWG Name: 00003705–106

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Figure 3
HYDROGEOLOGIC CROSS–SECTION LOCATIONS

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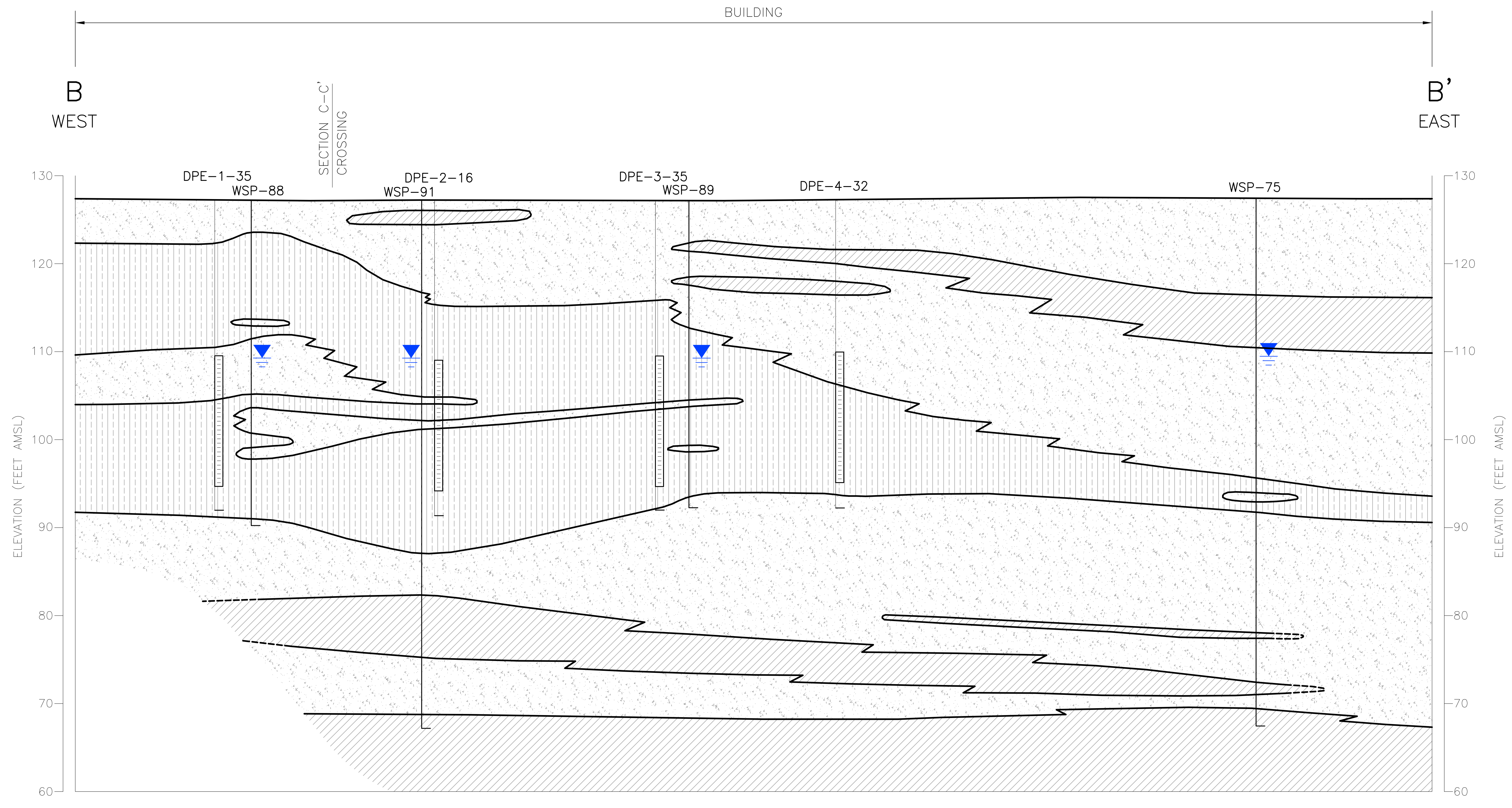
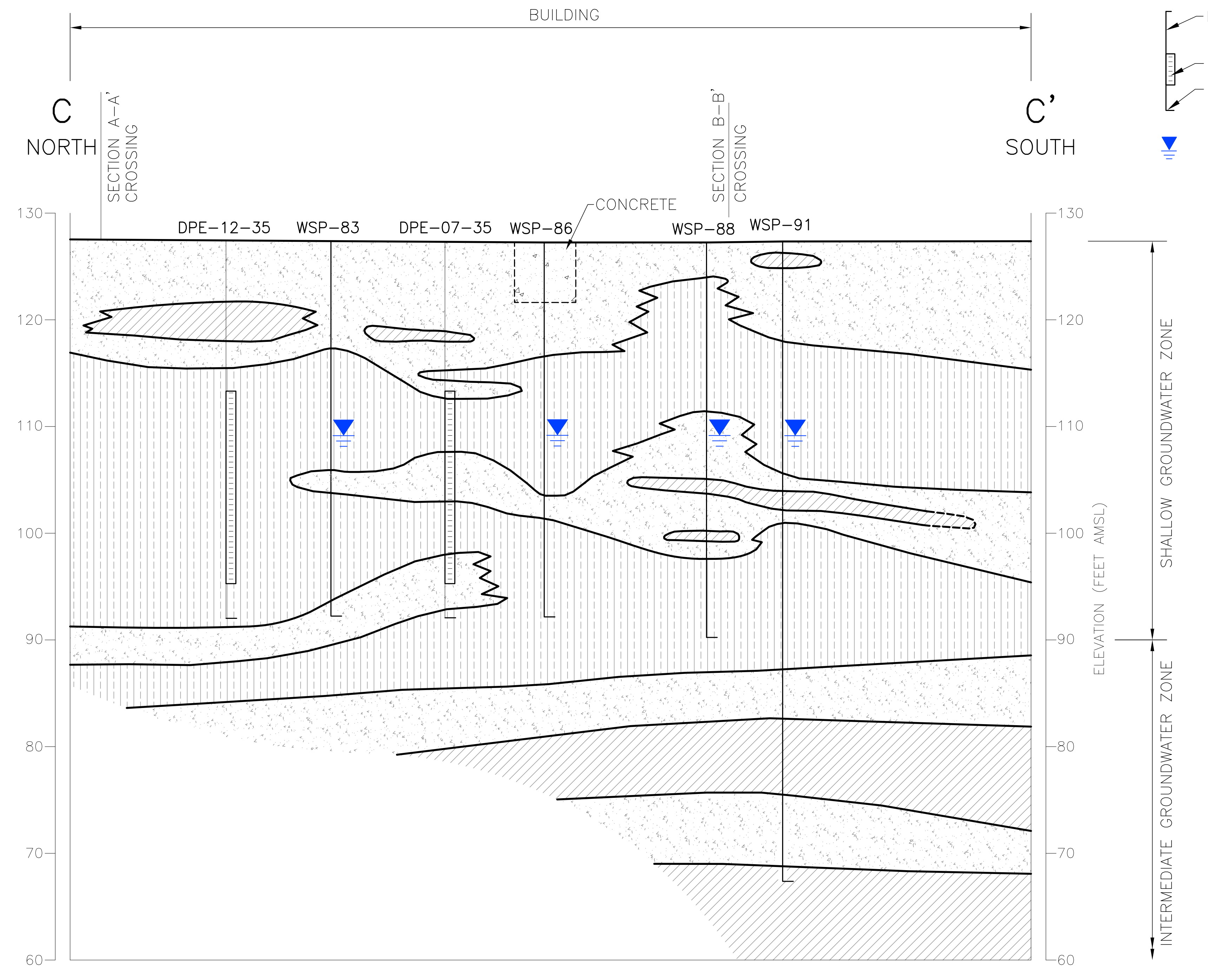




LEGEND

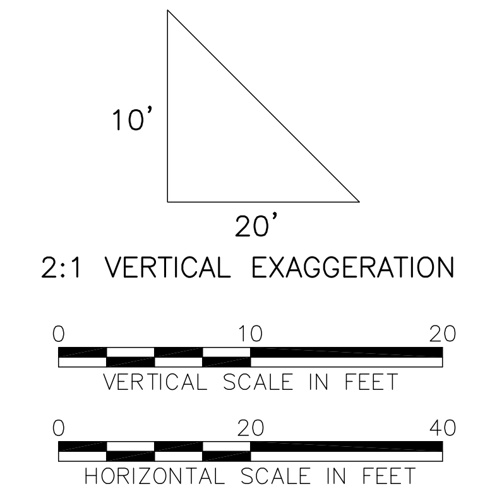
▨	SAND – SILTY SAND – CLAYEY SAND
▨	CLAY (SILTY – SANDY – GRAVELLY)
▥	INTERLAYERED AND INTERFINGERED CLAY (SILTY – SANDY – GRAVELLY) AND SILT (CLAYEY – SANDY)

BOREHOLE

WELL SCREEN

BOTTOM OF BOREHOLE

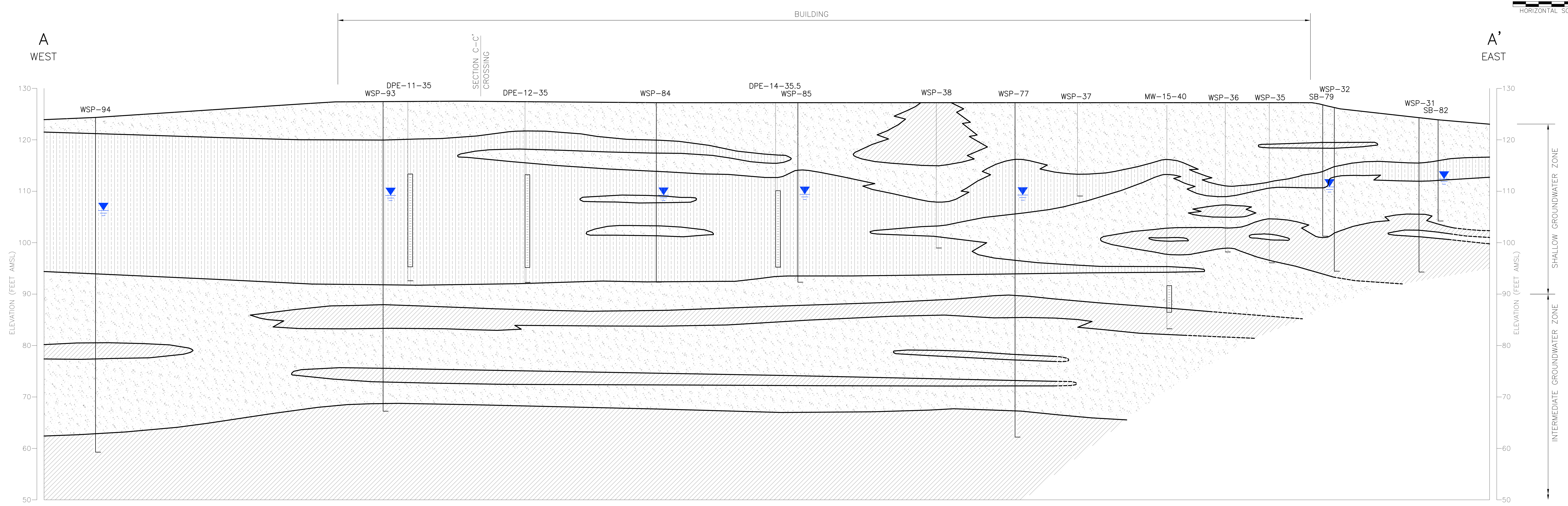
▼ WATER LEVEL DURING DRILLING



2:1 VERTICAL EXAGGERATION

VERTICAL SCALE IN FEET

HORIZONTAL SCALE IN FEET



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REVISIONS

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HYDROGEOLOGIC CROSS-SECTIONS A, B, AND C AREAS 1 AND 2

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FIGURE 4

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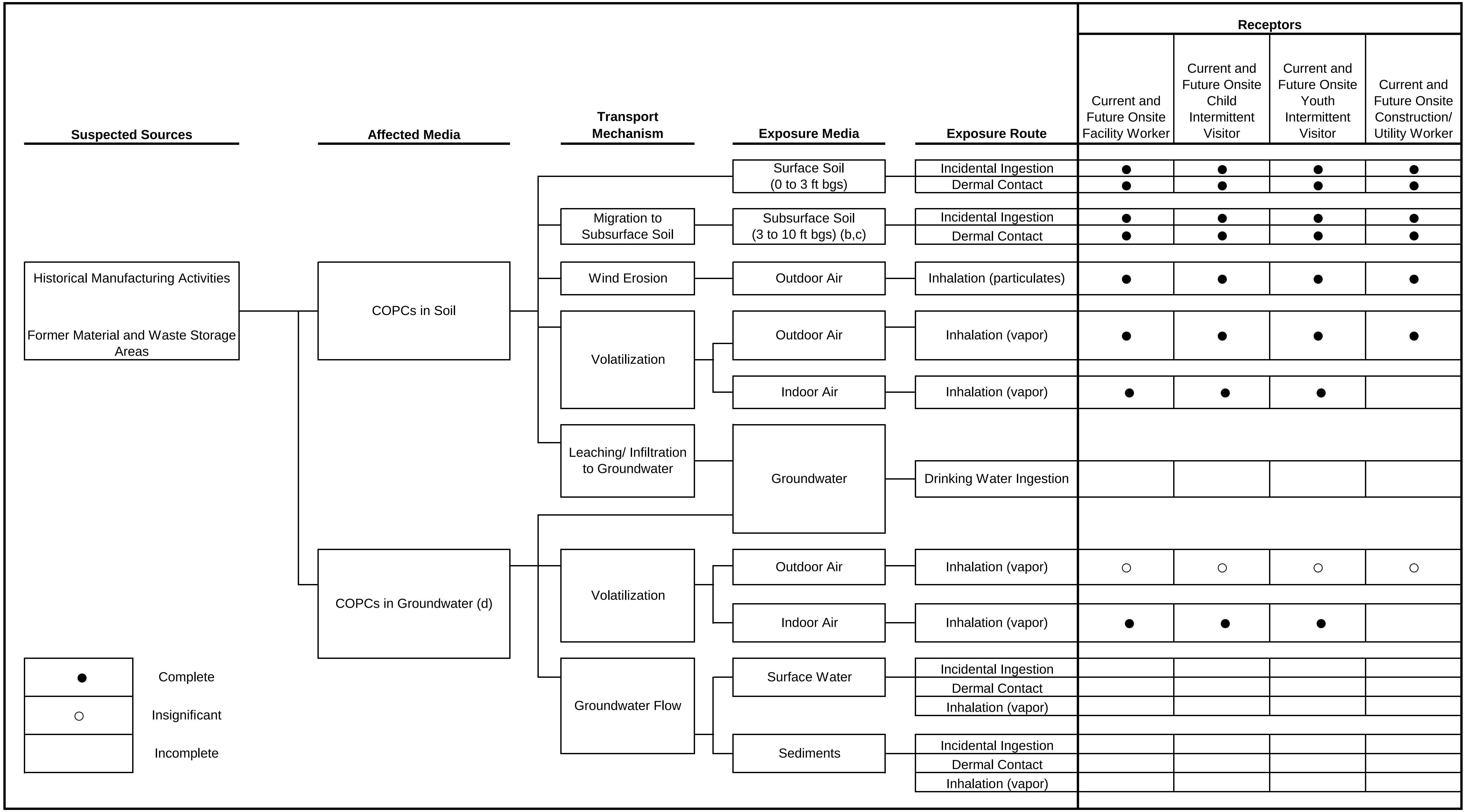
00003705–106

Figure 5
Conceptual Site Model - Human Health
Former Kop-Flex
Hanover, Maryland (a)



Suspected Sources	Affected Media	Transport Mechanism	Exposure Media	Exposure Route	Current and Future Onsite Facility Worker	Current and Future Onsite Child Intermittent Visitor	Current and Future Onsite Youth Intermittent Visitor	Current and Future Onsite Construction/ Utility Worker
Historical Manufacturing Activities Former Material and Waste Storage Areas	COPCs in Soil		Surface Soil (0 to 3 ft bgs)	Incidental Ingestion	●	●	●	●
				Dermal Contact	●	●	●	●
		Migration to Subsurface Soil	Subsurface Soil (3 to 10 ft bgs) (b,c)	Incidental Ingestion	●	●	●	●
				Dermal Contact	●	●	●	●
		Wind Erosion	Outdoor Air	Inhalation (particulates)	●	●	●	●
		Volatilization	Outdoor Air	Inhalation (vapor)	●	●	●	●
			Indoor Air	Inhalation (vapor)	●	●	●	
		Leaching/ Infiltration to Groundwater	Groundwater	Drinking Water Ingestion				
	COPCs in Groundwater (d)		Groundwater					
		Volatilization	Outdoor Air	Inhalation (vapor)	○	○	○	○
			Indoor Air	Inhalation (vapor)	●	●	●	
		Groundwater Flow	Surface Water	Incidental Ingestion				
				Dermal Contact				
				Inhalation (vapor)				
			Sediments	Incidental Ingestion				
				Dermal Contact				
				Inhalation (vapor)				

●	Complete
○	Insignificant
	Incomplete

a/ ft bgs = feet below ground surface: COPCs = chemicals of potential concern.
b/ Contact with soil deeper than 10 feet bgs by any receptor is unlikely to occur. Nevertheless, soil samples to depth up to 15 feet bgs were considered in the exposure assessment.
c/ A facility worker, child visitor, or youth visitor is unlikely to be exposed to subsurface soil. Complete pathway is assumed because of the possibility that subsurface soil could be brought to the surface.
d/ Groundwater migration offsite will be evaluated under a separately submitted work plan.

Tables

Table 1
Screening of Soil Sampling Results
Former Kop-Flex
Hanover, Maryland

Parameters (a)	Maximum (b)	Maryland Non-Residential Standard (c)	EPA RSL Industrial Soil (d)
VOCs (mg/kg)			
Acetone	6	92,000	67,000
Bromoform	0.006	360	290
2-Butanone	1.32	61,000	19,000
Carbon disulfide	0.063	10,000	350
Carbon tetrachloride	0.0058	22	2.9
Chlorobenzene	0.006	2,000	130
Chloroethane	1.5	990	5,700
Chloroform	0.031	1,000	1.4
1,1- Dichloroethane	7.5	20,000	16
1,2- Dichloroethane	0.0228	31	2
1,1- Dichloroethene	15	5,100	100
cis-1,2-Dichloroethene	1.5	1,000	230
1,4-Dioxane	6.94	NE	23
Ethylbenzene	0.008	10,000	25
2-Hexanone	0.011	NE	130
4-Methyl-2-Pentanone	0.073	NE	5,600
Methylene Chloride	0.47	380	320
1,1,2,2-Tetrachloroethane	0.011	1.4	2.7
Tetrachloroethene	0.17	5.3	39
Toluene	0.46	8,200	4,700
1,1,1-Trichloroethane	230	200,000	3,600
Trichloroethene	1.6	7.2	1.9
Vinyl Chloride	1.5	4.0	1.7
Xylenes	1.5	20,000	250
SVOCs (mg/kg)			
Fluoranthene	0.0355	4,100	3,000
Phenanthrene	0.0158	31,000	NE
Pyrene	0.0199	3,100	2,300
PCBs (mg/kg)			
Arcolor 1260	2.18	1.4	1.0
Metals and Cyanide (mg/kg)			
Aluminum	1,305	100,000	110,000
Antimony	1.24	41	47
Arsenic	13.5	1.9	3.0
Barium	9	20,000	22,000
Beryllium	0.913	200	230
Cadmium	7.64	51	98
Chromium (e)	295	150,000	180,000
Cobalt	1.6	NE	35
Copper	135	4,100	4,700
Lead	290	1,000	800
Mercury (f)	9.82	31	4
Nickel	390	2,000	2,200
Selenium	3.59	510	580
Silver	0.324	510	580
Thallium (g)	1.6	7.2	1.2
Vanadium	16.3	100	580
Zinc	378	31,000	35,000
Cyanide	3.46	2,000	13

a/ VOC = volatile organic compound; SVOC = semivolatile organic compound; PCB = polychlorinated biphenyl. Analytes detected in at least one sample are listed.

b/ Maximum concentration among all samples from depths no greater than 15 feet, excluding samples at locations and depths where soil was removed during remedial activities. For each analyte detected in a sampling event, concentration is assumed to be half the reporting limit for samples where not detected.

c/ Non-residential generic numeric soil cleanup standard (MDE 2008, Table 1).

d/ EPA Regional Screening Level (RSL) tables for industrial soil (January 2015), based on a target cancer risk of 1 x 10^{-6} and noncancer hazard index of 0.1.

e/ Chromium is assumed to be trivalent, as there is no history of storage or use of hexavalent chromium compounds on the property.

f/ Total mercury concentration was reported in laboratory analyses. Maryland standard applies to inorganic mercury. EPA RSL value applies to total mercury and supercedes the MDE cleanup standard in this case.

g/ Maximum concentration does not exceed Anticipated Typical Concentration of 3.9 mg/kg for eastern Maryland (MDE 2008, Appendix 2).

Table 2
Screening of Soil Vapor and Indoor Air Sampling Results
Former Kop-Flex
Hanover, Maryland

VOCs (μg/m^3) (a)	Maximum Soil Vapor (b)	Soil Vapor Screening Level (c)	Maximum Indoor Air (b)	Indoor Air Screening Level (c)
Acetone	2,400	1,400,000	49	14,000
Benzene	14	160	0.32	1.6
Carbon disulfide	1.7	31,000	0.54	310
Chloroform	2.0	54	ND	0.54
Chloromethane	0.59	4,000	1.0	40
Cyclohexane	ND	270,000	1.3	2,700
1,4-Dichlorobenzene	1.8	120	0.73	1.2
1,1-Dichloroethane	270	770	ND	7.7
1,2-Dichloroethane	1.1	48	ND	0.48
1,1-Dichloroethene	310	8,800	ND	88
cis-1,2-Dichloroethene (d)	2.3	NE	ND	NE
1,4-Dioxane	14	NE	ND	NE
Ethyl acetate	7.3	NE	1.1	NE
Ethylbenzene	2.0	500	1.5	5.0
4-ethyltoluene	2.9	NE	1.8	NE
Freon 11	1.4	31,000	1.4	310
Freon 113	6.1	1,400,000	ND	14,000
Freon 12	2.0	4,400	1.9	44
Heptane	1.7	NE	0.62	NE
Hexane	5.3	31,000	0.57	310
Isopropyl alcohol	170	NE	11	NE
Methyl Butyl Ketone	0.79	NE	ND	NE
Methyl Ethyl Ketone	23	220,000	4.3	2,200
Methyl Isobutyl Ketone	4.4	140,000	10	1,400
Methylene chloride	0.67	27,000	ND	270
Styrene	2.4	44,000	ND	440
Tetrachloroethylene	2.1	1,800	2.1	18
Tetrahydrofuran	12	88,000	ND	880
Toluene	9.6	220,000	ND	2,200
1,1,1-Trichloroethane	1,200	220,000	1.3	2,200
Trichloroethene	10	88	0.71	0.88
1,2,4-Trimethylbenzene	5.0	310	5.1	3.1
1,3,5-Trimethylbenzene	ND	220	1.1	2.2
2,2,4-Trimethylpentane	ND	NE	0.81	NE
Xylenes	7.9	4,400	6.3	44

a/ VOC = volatile organic compound. Compounds detected above the reporting limit in at least one soil vapor or indoor air sample are included in screening.

b/ Maximum concentrations in soil vapor and indoor air are based on maximum values for samples collected in May 2009.

c/ Values are derived from Maryland Tier I screening levels for soil vapor and indoor air on commercial properties (MDE 2012). The indoor air screening levels are based on a cancer risk of 1×10^{-6} and noncancer hazard quotient of 0.1 (0.1 times the values listed in MDE 2012). Soil vapor screening levels are 100x the indoor air screening levels. Concentration above a screening level is shaded.

Table 3
Summary of Exposure Point Concentrations
Former Kop-Flex
Hanover, Maryland

Soil (mg/kg) (a)	**EPC (a)**
PCBs (Aroclor 1260)	2.18
Arsenic	3.90
Mercury	1.65
Indoor Air (mg/m^3) (b)	
1,2,4-Trimethylbenzene	0.0051

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a/ EPC = exposure point concentration; PCBs = polychlorinated biphenyls. Soil EPCs are based on maximum concentration (PCBs) or 95% upper confidence limit of the mean (arsenic and mercury).
b/ EPC is based on maximum indoor air concentration.

Table 4
Exposure Factors
Former Kop-Flex
Hanover, Maryland (a)

			Receptor			
Parameter Code	**Parameter Definition**	**Parameter Units**	**Facility Worker**	**Construction Worker (c)**	**Child**	**Youth**
PEF	Particulate emission factor (b)	m^3/kg	1.4E+09	1.4E+09	1.4E+09	1.4E+09
IR_{soil}	Soil Ingestion rate	mg/day	50	330 (d)	200 (f)	100 (f)
SA	Exposed surface area, soil contact	cm^2/day	3,470	3,470	2,350 (f)	4,320 (f)
AF	Adherence factor	mg/cm^2-event	0.12	0.3 (e)	0.2 (f)	0.2 (f)
BW	Body weight	kg	80	80	15	40 (f)
EV	Event frequency, soil contact	events/day	1	1	1	1
ET	Exposure time, air	hours/day	8	8	4 (f)	4 (f)
EF	Exposure frequency, soil contact	days/year	250	250 (d)	132 (f)	132 (f)
ED	Exposure duration	years	25	1 (d)	6 (f)	12 (f)
AP_{nc}	Averaging period - noncancer	days	9,125	365	2,190 (f)	4,380 (f)
AP_c	Averaging period - cancer	days	25,550	25,550	25,550	25,550

a/ All values are from Recommended Default Exposure Factors (EPA 2014a), except where indicated. NA = not applicable to the receptor.

b/ PEF for all receptors is default value from Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA 2002b), Equation 4-5.

c/ Parameter values for construction worker are assumed to be the same as for facility worker except where indicated. All values are consistent with the EPA Regional Screening Level User's Guide.

d/ IR_{soil}, EF, and ED for construction worker are from Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA 2002b), Exhibit 5-1.

e/ AF for construction worker is from Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (EPA 2004b), Exhibit C-3 (95th percentile value for construction worker).

f/ Child and youth values are from MDE 2008, Appendix 1.

Table 5
Calculation of Soil Volatilization Factors
Former Kop-Flex
Hanover, Maryland

	Chemical-Specific Parameters (a)				Calculated Values (b)			
					Chronic		Subchronic	
Compound	D_a cm^2/s	D_w cm^2/s	H Unitless	K_d cm^3/g	D_A cm^2/s	VF m^3/kg	D_A cm^2/s	VF m^3/kg
Mercury	3.10E-02	6.10E-06	0.47	52	1.42E-05	3.00E+04	1.42E-05	6.81E+03

Soil Properties and Other Non-Chemical Properties (c)

			Chronic	Subchronic
Air-filled porosity	θ_a	Unitless	0.28	0.28
Water-filled porosity	θ_w	Unitless	0.15	0.15
Total porosity	η	Unitless	0.43	0.43
Bulk density	ρ_b	g/cm^3	1.5	1.5
Exposure time	T	s	7.88E+08	3.15E+07
Ratio volatilization flux to concentration in center of area	Q/C_{sa}	g/m^2-s per kg/m^3	68.18	14.3
Dispersion correction factor	F_D	Unitless	--	0.185

a/ Chemical parameters are from EPA Regional Screening Levels table (January 2015). D_a = diffusivity in air; D_w = diffusivity in water; H = Henry's Law constant; K_d = soil/water partition coefficient (elemental mercury).

b/ D_A = apparent diffusivity; VF = volatilization factor. D_A and VF are calculated using EPA 2002, Equation 4-8 (chronic) and Equation 5-14 (subchronic).

c/ Default values from EPA 2002b, Equation 4-8 (chronic) and Equation 5-14 (subchronic). Exposure time values are 25 years (chronic) and 1 year (subchronic).

Table 6

Toxicity Values
Former Kop-Flex
Hanover, Maryland

Indoor Air COPCs

	RfC mg/m^3		RfC Construction mg/m^3		IUR (mg/m^3)$^{-1}$
1,2,4-Trimethylbenzene	7.00E-03	P	7.00E-03	P	NA

Soil COPCs

	RfD mg/kg-d		RfD Construction mg/kg-d		RfC mg/m^3		RfC Construction mg/m^3		SF (Oral) (mg/kg-d)$^{-1}$		IUR (mg/m^3)$^{-1}$		ABS$_d$ (c)
PCBs (Aroclor 1260)	NA		NA		NA		NA		2.00E+00	I	5.70E-01	I	1.40E-01
Arsenic	3.00E-04	I	3.00E-04	I	1.50E-02	C	1.50E-02	C	1.50E+00	I	4.30E+00	I	3.00E-02
Mercury	3.00E-04	I	3.00E-03	I	3.00E-04	I	3.00E-04	I	NA		NA		1.00E-01

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a/ COPC = chemical of potential concern; RfD = reference dose; RfC = reference concentration, SF = slope factor; IUR = inhalation unit risk . Sources: C = California Environmental Protection Agency; I = Integrated Risk Information System; P = Provisional Peer-Reviewed Toxicity Values (PPRTV). NA = not applicable or not available.

b/ RfC values not available; values for trans-1,2-dichloroethene are listed.

c/ ABS$_d$ = dermal absorption factor. Source for PCBs and arsenic: EPA 2004b. Source for mercury: EPA 1995.

Table 7

Risk Summary
Former Kop-Flex
Hanover, Maryland (a)

Receptor	Source Medium	Exposure Medium	Exposure Point	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Dermal	Inhalation	Exposure Point Total	Exposure Medium Total	Ingestion	Dermal	Inhalation	Exposure Point Total	Exposure Medium Total
Current or Future Facility Worker	Soil	Soil	Soil	1.2E-06	1.0E-06	1.0E-09	2.2E-06	2.2E-06	5.7E-03	3.4E-03	4.2E-02	5.1E-02	5.1E-02
	Soil/Groundwater	Air	Indoor Air			0.0E+00	0.0E+00	0.0E+00			1.7E-01	1.7E-01	1.7E-01
							Receptor Total	2E-06				Receptor Total	2E-01
Future Construction Worker	Soil	Soil	Soil	3.2E-07	1.0E-07	4.2E-11	4.2E-07	4.2E-07	2.4E-02	4.0E-03	1.8E-01	2.1E-01	2.1E-01
							Receptor Total	4E-07				Receptor Total	2E-01
Current or Future Child Visitor	Soil	Soil	Soil	3.3E-06	7.6E-07	6.6E-11	4.0E-06	4.0E-06	6.4E-02	1.1E-02	1.1E-02	8.6E-02	8.6E-02
	Soil/Groundwater	Air	Indoor Air			0.0E+00	0.0E+00	0.0E+00			4.4E-02	4.4E-02	4.4E-02
							Receptor Total	4E-06				Receptor Total	1E-01
Current or Future Youth Visitor	Soil	Soil	Soil	1.2E-06	1.1E-06	1.3E-10	2.3E-06	2.3E-06	1.2E-02	7.3E-03	1.1E-02	3.0E-02	3.0E-02
	Soil/Groundwater	Air	Indoor Air			0.0E+00	0.0E+00	0.0E+00			4.4E-02	4.4E-02	4.4E-02
							Receptor Total	2E-06				Receptor Total	7E-02

a/ Target values are ≤1 for non-cancer hazard and ≤ 1E-05 for cancer risk.

Table 8
Screening of Surface Water Sampling Results
Former Kop-Flex
Hanover, Maryland (a)

	Upstream		Downstream	Screening Levels			
				Ecological		Human Health	
Sample Name:	**WL-1**	**WL-1D**	**WL-2**	**Maryland (b)**	**EPA (c)**	**Maryland (d)**	**EPA (e)**
Sample Date:	**10/22/98**	**10/22/98**	**10/22/98**				
SVOCs (µg/kg)							
Bis-2-ethylhexyl phthalate	2 J	1 J	10 U	NE	NE	12	1.2
Di-n-butyl phthalante	14 U	12 U	1 J	NE	NE	2,000	2,000
Inorganics (mg/kg)							
Barium	57.8	65.7	57.9	NE	NE	1,000	1,000
Cyanide	5.0	5.0	5.0	5.2	5.2	140	140
Iron	124	157	1,770	1,000	1,000	NE	NE
Manganese	20.4	24.6	160	NE	NE	NE	50 (f)
Zinc	13.3	13.8	13.6	120	120	7,400	7,400

a/ U = Not detected at reporting limit. J = estimated value below reporting limit; SVOC = semivolatile organic compound; NE = not established. Detected concentrations above ecological screening value are highlighted and above human health screening value are boxed. Chemicals detected in at least one sample are listed. Surface water samples were also collected in 2001 and analyzed for volatile organic compounds, but none were detected.

b/ Numerical Criteria for Toxic Substances in Surface Water, COMAR 26.08.02.03-2, chronic fresh water value for aquatic life.
c/ EPA, National Recommended Water Quality Criteria, Aquatic Life Criteria Table (chronic value).
d/ Numerical Criteria for Toxic Substances in Surface Water, COMAR 26.08.02.03-2, human health value for consumption of organism and drinking water.
e/ EPA, National Recommended Water Quality Criteria, Human Health Criteria Table (water and organism).
f/ Listed value is the secondary maximum contaminant level, which is based on taste and potential staining of laundry, not on human health.

Table 9
Screening of Sediment Sampling Results
Former Kop-Flex
Hanover, Maryland (a)

	Upstream		Downstream	Ecological Screening Levels	
Sample Name:	**WL-1**	**WL-1D**	**WL-2**	**EPA Region 3 (b)**	**TEL (d)**
Sample Date:	**10/22/98**	**10/22/98**	**10/22/98**		
VOCs (µg/kg)					
Carbon disulfide	8	7 U	9 U	0.851	NE
Methylene chloride	4 J	4 J	9 U	NE	NE
Toluene	6 J	7 U	15	NE	NE
Inorganics					
Aluminum	543	946	1,930	NE	25,500 (e)
Barium	2.2	3.3	13.8	NE	NE
Chromium	2.1	2.9	10	43.4	37.3
Copper	1.5	2.1	11.1	31.6	35.7
Cyanide	0.26	0.34	0.33	0.1 (c)	NE
Iron	662	1,220	5,670	20,000	20,000 (f)
Lead	0.95	1.6	7.1	35.8	35.0
Manganese	1.4	2.0	11.4	460	460 (f)
Vanadium	4.2	6.8	21.8	NE	NE
Zinc	13.0	20.7	9.3	121	123

a/ U = Not detected at reporting limit. J = estimated value below reporting limit; VOC = volatile organic compound; NE = not established. Detected concentrations above ecological screening value are highlighted. Chemicals detected in at least one sample are listed.

b/ EPA Region III Freshwater Sediment Screening Benchmarks, August 2006.
c/ Screening value applies to free cyanide. Sample analyses report total cyanide.
d/ TEL = threshold effect level for freshwater sediment. Values were taken from National Oceanic and Atmospheric Administration Screening Quick Reference Tables (SQuirT; Buchman 2008).
e/ TEL value for Hyalella azteca from the Assessment and Remediation of Contaminated Sediments program.
f/ TEL not available; lisetd value is Lowest Effects Level.

Appendix A – Summary of Soil Sampling Locations and Analytical Results

Appendix B – Summary of Soil Vapor and Indoor Air Analytical Results

Appendix C – Summary of Surface Water and Sediment Analytical Results

Appendix D – Calculation of Upper Confidence Limit of Mean Arsenic and Mercury Concentrations in Soil

Appendix E – Calculations of Non-Cancer Hazards and Cancer Risks

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